ANNALS

of the

Association of American Geographers

Volume XXX SEPTEMBER, 1940 No. 3

World View of Destruction and Conservation of Natural Resources

J. R. WHITAKER

A problem of growing concern is the destruction of natural resources and the reaction of that destruction on man himself. Too commonly treated as a phase of the economic nationalism of recent years,[1] the problem is more properly viewed as world-wide in scope and pre-historic in origin.

The nineteenth and twentieth centuries have, however, witnessed the tendency of this problem to develop beyond the point where it could easily be solved by migration,[2] so that it now requires more complicated measures. We must agree with Woeikof, who asserted in 1901 that the civilization which had developed during the nineteenth century was disharmonious with nature to a supreme degree.[3] More recently Mill summed up the situation as follows: "If the influence of the land on the life of Man has been reduced in the last hundred years from a tyranny to a doubtful hint, the reaction of Man on the economy of the world has grown from a jest to a serious menace. The disturbance of the balancing harmony of plant and animal distribution and the exhaustion of mineral deposits has no precedent in the life of species other than *Homo sapiens,* and unless he vindicates his name by bringing reason to the rescue of his future, there is no doubt that Nature will ultimately take

[1] Harold A. Innis: The Economics of Conservation, *Geogr. Rev.,* Vol. 28, 1938, pp. 137–138.

[2] V. Gordon Childe: *Man Makes Himself,* London, 1936, p. 82.

[3] A. Woeikof: De l'influence de l'homme sur la terre, *Annales de Géogr.,* Vol. 10, 1901, p. 207.

the matter in hand and restore equilibrium in her own drastic and remorseless way."[4]

The present century, or at least the last 100-year period, differs, too, from preceding times in the more general recognition of this problem. Although such books of wisdom as Genesis contain numerous conservation principles, it was not until all peoples had come under the surveillance of the more thoughtful groups of mankind that the possible consequences of the destructive exploitation of nature could be envisaged. Civilizations may have "risen and fallen without apparently perceiving the full import of their relations with the earth," and soil and mineral exhaustion may have been felt locally in other periods of history "without stirring the rulers of the threatened communities to take effective measures against these dangers."[5] It is unlikely, however, that such ignorance of possible results will ever exist again, and it is the faith of conservationists that efforts will continue to be made to counteract the destructive effects of man on the earth.

The record of destructive and conservative use of natural resources is being written on many fronts. Much less attention has been given, quite naturally, to the ideas and methods of the men who have assumed the responsibility for preparing that record. An evaluation, for the period 1864-1938, of portions of this written record is the immediate aim of this essay. In tracing the history of ideas regarding resource destruction and conservation, I start with George P. Marsh, and follow one line of his intellectual descendants. This critique is limited to the writings of men who dealt with the problem, as he did, from a world point of view. Because each of these writers depended on scores of investigators for the primary data and ideas on which to base his generalizations, this study is, perforce, more than a review of the work of a few men. It aims, instead, at a somewhat comprehensive grasp of the history of thought on resource destruction and conservation as a phase of human occupance of the earth as a whole, and, as a means to that end, samples the best of the pertinent geographic literature published within the last century.

GEORGE P. MARSH[6]

George P. Marsh published his *Man and Nature* in 1864. He set four main objectives before himself: to indicate the character and extent of the

[4] Hugh Robert Mill: An Approach to Geography, *Geography*, Vol. 18, 1933, p. 16.

[5] Lewis Mumford: *Culture of Cities*, New York, 1938, p. 322.

[6] George P. Marsh (1801–1882), distinguished New England jurist and scientist, published what seems to have been the first comprehensive survey of the problem. His book, *Man and Nature; or Physical Geography as Modified by Human Action*, appeared in 1864. A revision was issued in 1874 as *The Earth as Modified by Human Action* (Scribner, Armstrong and Co., New York).

changes produced by human action in the physical conditions of the earth; to point out the dangers of imprudence and the necessity for caution in all operations which, on a large scale, interfere with the balance of nature; to suggest the possibility and the importance of the restoration of disturbed harmonies and the material improvement of waste and exhausted areas; and to illustrate the thesis that man is, in both kind and degree, a power of a higher order than any of the other forms of animal life which, like him, are nourished from the same source.

In discussing the character of the changes made by man, Marsh ranged from the destruction of forests to the possible consequences of the construction of inter-oceanic canals. For each he raised problems which continue to plague us, such as the meteorological consequences of deforestation, modifications of the ground-water table and the flow of springs, forests in relation to torrents, sea-coast erosion, the relations between land reclamation and social action through governmental agencies, the flood problem, and the control of wind erosion. Particularly dear to him was the idea that man-induced changes in the native vegetation affect nearly all other elements in the natural complex.

To indicate the world-wide extent of changes produced by man was an objective hardly attainable in Marsh's time, and perhaps not fully realizable today. Yet we must credit Marsh, who supported his generalizations with specific instances drawn mainly from Europe, North Africa, and North America, with a remarkable command of the evidence then available. His illustrations did not, however, provide a world-wide inventory of human modifications of natural resources. Even today, such an assessment has been attempted for forests and soils only.[7] The time is now at hand when world maps to show the extent of man-induced changes in other resources might well be prepared. Here, in the nature and distribution of human alterations of natural phenomena, is a challenge to which geographers and other students of man's natural environment have not as yet made adequate response.

Although Marsh approached these problems from the point of view of an avowed physical geographer, he did not neglect social causation. In his discussion of the deterioration and melioration of land in southern Italy, he has a masterly analysis, on the one hand, of the correlation of deterioration with decline in social consciousness and the effectiveness of the central governing agency; and of the coincidence, on the other hand, of periods of

[7] A world survey of existing forest resources is found in Raphael Zon and William N. Sparhawk: *Forest Resources of the World,* New York, 1923. For soil exploitation, see Hugh H. Bennett: *Soil Conservation.* New York, 1939; and G. V. Jacks and R. O. Whyte: *Vanishing Lands; A World Survey of Soil Erosion,* New York, 1939.

melioration with periods of responsible, far-sighted government. Similar conclusions were presented for Palestine. Indeed, one may be justified in arriving at a very significant generalization for those areas in which there is a relatively unstable (easily damaged) natural resource complex: that land will be conserved only if the general good is being consciously sought by a social agency of intelligence and competence.

To point out the dangers of imprudence and to sound a word of warning against large-scale interference with nature is even more appropriate today. Indeed, in the very efforts of nations to better conditions within their national domain we find the danger in as serious a form as when their action is deliberately devastative. One cannot help a feeling of apprehension in reading the confident accounts by Marshak and Mikhailov[8] of the ways in which drainage and other natural features are being "improved" in parts of the U.S.S.R. Their assumption that man now has it within his power, socially as well as technically, to remake nature to his own ends without risk of doing just the opposite would be questioned in many quarters today. Programs of land reclamation, may, for example, end in land destruction; and large-scale alteration of drainage systems may, in the end, actually do more damage than good.

We must revise Marsh's estimate of the possibilities of "physical conservation and restoration," because, since his day, the "vast unoccupied prairies and forests" in America, in Australia, and in other areas have ceased to exist. Like him, we may consider the preservation of these primitive geographical features as an end much to be desired, but we know that since his time these lands have been the seat of destructive occupance of a violence unparalleled in the older countries. Since his day the earth has filled up; there now are no unclaimed and unexploited lands of notable natural wealth, where the population is negligible in numbers or is being thinned out by the diseases of new comers. Movement on to richer areas, which has been the expedient employed since man first practiced shifting agriculture or moved his tent to fresh pastures or hunting grounds, is no longer feasible. Men must come to terms with the necessity of husbanding the resources of their home area.

Lastly, we may note Marsh's thesis that man is above other animals, all nature in fact. That this is a dangerous notion is suggested by the writings of Mikhailov and Marshak. It is a part of the ideology behind the unrestrained appropriation of all natural resources. On the other hand, it is also basic to all efforts at resource improvements, to all planning of land utilization in fact. That lower forms of life do actually take steps to pre-

---

[8] Marshak, Ilia: *Men and Mountains*, London, 1936. Mikhailov, N.; *Soviet Russia*, 2nd edn., London, 1937.

serve or improve their environment is taught us by the ants and beavers. But so far as we know, man alone of all creatures is able to worry about the future, and to make provision for meeting problems for which he did not inherit a solution. Here is sounded one of four of the major premises on which the "conservation movement" of the twentieth century appears to rest. These are, first, that human welfare depends on natural resources; second, that the continued welfare of man, and therefore the maintenance of a rich natural-resource base, is desirable in each major part of the world; third, that in occupying any area, man inevitably sets processes in motion, which, unless counteracted, bring about deterioration of critical elements in the natural resource complex; and fourth (the one which Marsh suggests), that man has it within his power to retard or to stop the depletion of resources of critical significance and even to increase the quantity and improve the quality of certain of the resources being utilized. Whether or not man is actually different from lower life forms in his concern for the future, any program for preservation and improvement of resources is predicated on the assumption that he can exercise effective forethought and restrain in planning for future needs.

Marsh provided a framework of ideology and knowledge which still serves us. Serious students of the destruction, preservation, or melioration of natural resources will long continue to acknowledge their indebtedness to him.

ÉLISÉE RECLUS

In *The Earth as Modified by Human Action,* Marsh called attention to the complementary work of Élisée Reclus: "Since the publication of the original edition, Mr. Élisée Reclus, in the second volume of his admirable work, *La Terre* (Paris, 1868), . . . has treated, in a general way, the subject I have undertaken to discuss. He has, however, occupied himself with the conservative and restorative, rather than with the destructive, effects of human industry, and he has drawn an attractive and encouraging picture of the ameliorating influences of the action of man, and of the compensations by which he, consciously or unconsciously, makes amends for the deterioration which he has produced in the medium he inhabits. The labors of Mr. Reclus, therefore, though aiming at a much higher and wider scope than I have had in view, are, in this particular point, a complement of my own."[9]

[9] George P. Marsh: *The Earth as Modified by Human Action,* New York, 1873, p. viii. Reclus' *La Terre* was translated under the general title, *A New Physical Geography,* edited by A. H. Keane. The section to which Marsh referred is in Volume 2, which is entitled The Ocean, Atmosphere, and Life. This book is available in at least two printings. The following citations are to the 1874 printing by Harper and Brothers, New York.

Patrick Geddes likewise recognized the essentially optimistic view of the author of *La Terre,* noting that he had no undue fear of the consequences of human modifications of nature, and that his books were not only a record of the conquest of nature by man but also an incitement to further conquest.[10]

In Book IV of *The Ocean, Atmosphere, and Life,* Reclus considered such themes as the reclamation of the earth by cultivation, the culture of marshes, the drainage of lakes and inland seas, dikes on the sea-shore, waterways, modifications of climate by man, the influence of man on the native flora and fauna, and the influence of man on the beauty of the earth.

His optimism is reflected in his statement that "there is no soil that man, impelled by necessity, and having at his disposal the enormous resources which are afforded him by the combined efforts of science and industry, can not transform into fertile fields."[11] There follow numerous instances of agricultural achievements.

In general, the tone of Reclus' writing is indeed such as to excite admiration for the works of man. But, more or less as asides, are numerous warnings regarding destructive aspects, accompanied by suggestions for improvement. The greater part of the farm land of the earth is worked, he maintains, by a system of soil mining; piecemeal drainage methods are shown to aggravate the land drainage problem downstream, and it is asserted that land drainage must be planned eventually for the whole area of each drainage basin; and the extinction of the whale is predicted. In one chapter he squarely faces the problem of destructive utilization: "The question as to how far the agency of man serves either to adorn or degrade the aspect of nature may seem an ideal [*i.e.,* purely academic] one to minds of a so-called positive tendency; but it none the less assumes an importance of the highest order. . . . Among the causes which, in the history of mankind, have effected the extinction of so many forms of civilization, we must place in the first order the reckless violence with which most nations have treated the soil which nourished them."[12]

Reclus, too, recognized the social implications involved in his theme. "This action of man," he says, "may embellish the earth, but it may also disfigure it; according to the manner and social condition of any nation, it contributes either to the degradation or glorification of nature."[13] In harmony with his disbelief in the efficacy of governments, he stops short, however, of

[10] Patrick Geddes: A Great Geographer, *Scot. Geog. Mag.,* Vol. 21, 1905, pp. 490–496, 548–552. Reference is to p. 495.

[11] Élisée Reclus: *op. cit.,* pp. 470–471.

[12] *Ibid,* p. 523.

[13] *Ibid,* p. 522.

accepting the safeguarding of natural resources as one of the obligations of the state.

Repeated acknowledgments to Marsh's *Man and Nature* show that Reclus profited much from this earlier work. It appears, indeed, that Reclus deliberately chose to supplement the work of Marsh by making his own study primarily a eulogy to the creative power of man. In truth, Reclus is an idealist: his emphasis on the preservative and meliorative influence of man on nature is based not on ignorance of the destruction already wrought but on the faith that man can make a better world. Following a quotation from *La Montagne* by Michelet to the effect that as a consequence of the destruction of certain desirable plants and animals and the increase of less desirable species, "Common-place ideas and things will prevail," Reclus adds: "Oh, no; the ideal of man is the ideal which will always prevail. As long as this ideal is nothing else but the mere reclamation of ground for cultivation, everything will be sacrificed to this point—the variety and originality of species, and all the beauty of vegetation; but when the desire of obtaining productive crops from the earth is supplemented by that of adorning it and of giving it all the splendor which art adds to nature; . . . no doubt it [agriculture] will succeed in materially modifying the vegetable world, according to its desire, and in giving it, instead of its primitive originality a new beauty which will respond to a sentiment of aesthetic taste."[14] We cannot but admire the faith of Reclus in mankind, even though we have serious reservations regarding man's ability to improve on the "primitive originality" of native vegetation, if beauty is the objective. Reclus closes with a statement of his hopes for more harmonious relations between man and nature and of his conception of the changes which are required to bring about that desired state: "Although science may bring before our eyes the distant future of a glorified earth, she alone can not bring to perfection this great work. A moral progress must necessarily correspond with this progress in knowledge. . . . The features of the globe will never assume their perfect harmony until men are united in one league of justice and peace."[15]

A. WOEIKOF

From Reclus, a Frenchman, we turn to the work of the Russian Woeikof, one time professor of physical geography in the University of St. Petersburg.[16] In the introduction to his discussion of the influence of man on the earth, Woeikof refers specifically to *La Terre* by Reclus. He notes that Reclus has taken account of recent developments, but has treated the ques-

[14] *Ibid,* p. 519.

[15] *Ibid,* p. 530.

[16] A. Woeikof: De l'influence de l'homme sur la terre, *Annales de Géogr.,* 10, 1901, pp. 97–114; 193–215.

tion very differently from the way he himself proposes. Indeed the differences are striking.[17]

Reclus considered the earth as made for man according to a Divine plan. Woeikof, like Marsh, was little if at all concerned with discovering evidences of a Divine purpose. Although Woeikof specifically refers at no point to Marsh, his study of Reclus, who leaned heavily on Marsh, makes it reasonable to assume a debt to the earlier writer. Certainly in objectivity and freedom from teleological assumptions, Woeikof is a lineal descendant of the American scholar.

Woeikof treats of "movable bodies" and vegetation; gully erosion; black waters and silt-laden streams; deforestation; moving sands and karst; drainage, irrigation and construction of reservoirs; snow and avalanches; the influence of man on the temperature of the air; his influence on winds, rains, and gullies; reasons for the destructive effects of man on nature; the numbers of people the earth can support; and the future use of sun's rays and of waters.

His approach is that of the physical scientist, though he reverses the usual approach of physical scientists to man-earth relations: his interest is, it appears, fundamentally in the influence of man on nature rather than of nature on man. Moreover, he is thinking of the influence of man both (1) on natural elements of human significance, and (2) on natural elements of no known relation to human welfare. This distinction is not always easy to make, but it is a fundamental one. The first approach involves a functional evaluation of natural factors in terms of the desires and capacities of particular peoples. The second avoids this problem but, in turn, includes the study of human influence on natural phenomena of no known significance in the human habitat. Woeikof was interested primarily in human activities as processes molding the face of the earth, and secondarily in the reactions of those changes on the human agency.

One of the more frequently quoted statements made by Woeikof relates to "les corps meubles." Woeikof notes that man's influence on nature is insignificant so far as the *forces* of nature are concerned, but that he is particularly effective through his attack on (1) movable bodies (*les corps meubles*), (2) interior waters, (3) the vegetation, and (4) the surface of the earth. Under movable bodies Woeikof includes lithic elements only: (1) soil and subsoil; (2) terrestial sands and gravels; (3) water-borne materials, varying from clay to boulders; and (4) dust and sand carried by the wind. Woeikof did not use this idea of influence on movable objects to include all that man does to nature, although he might well have done so. As John Stuart Mill pointed out a half century before, everything that man

[17] *Ibid*, p. 98.

does to the material world consists in *moving* objects, nature doing the rest. "This operation, of putting things into fit places for being acted upon by their own internal forces, and by those residing in other natural objects, is all that man does, or can do, with matter."[18]

Woeikof recognized, as did Marsh, that the most effective control over these lithic materials lies in modifications of the vegetation, and the history of soil erosion control bears him out. He concludes, prophetically, that these movables may be controlled by man on condition that he studies nature and works with great care; otherwise "the very mobility of these materials may prove fatal to man and his works."

Gullies receive much attention. Woeikof asserts he has never found active gullying in any wooded or grassland area except where man had interfered, and he cites the black soil area of southern Russia as one in which devastative gullying has occurred. The erosional phenomena in south and central Russia are perhaps no better known today than in Woeikof's day, although Mikhailov also recognizes the seriousness of the problem. The summary, by Woeikof, of causes of gullying is worth noting,[19] as is the entire omission of any reference to sheet erosion.

A distinction is made between "black rivers" (the dark water from forested or swampy areas) and streams which are heavily laden with silt. The latter Woeikof correlates with man-induced erosion. To him, the dissection of the loess of China is a remarkable case of man-induced erosion and the silt in the Hoang Ho a consequence of it.

The discussion of deforestation develops, among other themes, the way in which gully formation and land abandonment account for the extension of forests from valleys to intervening grass uplands in southern Russia. Noteworthy too are his examples of human modification of forest by ax and fire in the so-called virgin forest—the Taiga. The part of man in liberating sands from their vegetational bonds is clearly shown in Russia. By generalizing on karst areas in various parts of the earth, Woeikof concludes that the barrenness of the karst of the Balkans is due to deforestation in an area of delicate balance between weathering and erosion.

The drainage of marshes has presented a particularly grave problem in Russia and still does. Examples of irrigation are drawn from other lands. Reservoirs are suggested for southern Russia similar to those now being planned and constructed in that country.

Woeikof's analysis of the relations between human alteration of vegetation and snow cover calls to mind recent experiments of the Soil Conservation Service. He notes that snow remains longer in forests and in virgin

[18] John Stuart Mill: *Principles of Political Economy,* London, 1848. Vol. 1., p. 32.

[19] Woeikof: *op. cit.,* pp. 102–103.

steppes than in cultivated fields. Much has since been made of the first relation; the second has been little considered, although noted recently by Rockie for the Palouse.[20] The desirability of conserving snow in various ways is made clear.

To the vexing problem of the influence of man on climate, Woeikof devotes much space. He concludes that as man modifies the surface of the land, he perforce changes the temperature and humidity of the air above. The thesis that forested areas have more rain than deforested ones is advocated—a question still unsettled. Reverting to his favorite theme of gully erosion, he notes that ravines which have resulted from man-induced erosion (1) make for a diversity of micro-climates; (2) dry out the soil and raise the temperature of the soil in summer; and (3) promote air drainage in winter when the land is rather bare, with the result that a gullied upland is warmer than one not so eroded.

Woeikof next stresses the unfortunate consequences of man's influence on nature. A part of the damage has been repaired, or will be, he maintains, but not all: a part is related to the "world civilization" which exists at the opening of the twentieth century. And Woeikof sees in the factory and the city the chief nuclei of this relation. He holds that the city, like war, drains the best of rural manhood, thus robbing the country and, at the same time, creating social groups devoid of healing contact with the soil. We may question or support this thesis, but we can scarcely disagree with him that one of the indirect consequences of the growth of the city has been the destructive exploitation of colonial farmlands. He concludes that an intelligent occupation of the earth by man is prevented, despite his scientific technique, by the *growing dissociation of man and the earth,* as man becomes increasingly dominated by the world civilization epitomized in our great cities.

Woeikof concludes, in appropriate fashion for a student of physical earth science, with the proposal that for the future we should use the sun's rays as completely as possible, both directly and indirectly. The appeal of this resource rests for him, as it has for many, on its inexhaustibleness. Among the indirect expressions of solar energy are running water and wind. He recommends that by a wise combination of public works and measures of rural economy, we may retain the waters in lakes and reservoirs, and thus not let them go to the sea until they have done our work. The suggestion sounds like a platform for the Tennessee Valley Authority, and not unlike schemes in Russia today. He pleads for a more understanding and imaginative attitude toward our water resources. If we do control such resources to the full, and if we do take care to preserve other natural resources, this

[20] W. A. Rockie: Man's Effects on the Palouse, *Geogr. Rev.,* 1939, pp. 36–37.

writer feels that the dread of over-population—and he refers to the ideas of Malthus—will be set at rest. But, he adds, we will have to learn many things and forget many things, and he asserts that we were far removed from the desired state at the beginning of the twentieth century.

More effectively than Marsh, Woeikof established human modification of nature as one of the processes with which the professional physical geographer should concern himself. In carrying his study of earth features forward to human consequences and backward to the processes involved, he was working in accord with what W. M. Davis held to be the best procedure in physical geography.

ERNST FRIEDRICH

Our trail leads from Reclus and Woeikof to Ernst Friedrich. The next general account to be published, based on an attempt to generalize for the entire world, and clearly influenced by the thread of thought which received such vigorous amplification in Marsh's *Man and Nature,* was *Wesen und geographische Verbreitung der "Raubwirtschaft."*[21] Like Woeikof, Friedrich does not mention Marsh in this article, but elsewhere, in his critical bibliographies, he comments at considerable length on the work of Marsh, Woeikof, and Reclus.

Friedrich's work is noteworthy in at least two regards: he defines more sharply than had been done the meaning of *Raubwirtschaft* and related terms; and he describes the world distribution of the activities of resource depletion (though not the distribution of cumulative results). Friedrich narrows the question to one of human modification of those natural conditions which are clearly of value in the human habitat, economically, aesthetically, or intellectually. He does not display the interest which Woeikof had in all human changes in nature irrespective of their significance to man.

Wirtschaft is defined as the interaction of man and nature involved in meeting man's needs; the ideal, in satisfying those needs, being to preserve as completely as possible the resources involved, or better yet, to unlock new ones. This ideal he calls *rational Wirtschaft.* With regard to resource uses which involve no deliberate provision on man's part for resource maintenance, he distinguishes Sammelwirtschaft from Raubwirtschaft, and simple Raubwirtschaft from characteristic Raubwirtschaft. By *Sammelwirtschaft* (the nearest equivalent in English is "gathering" or "plucking") is meant the taking of natural resources without provision for restoration by man but not in excess of natural renewal. By *Raubwirtschaft* is meant taking which bears so heavily on nature that the natural endowment of the

[21] Ernst Friedrich: Wesen und geographische Verbreitung der "Raubwirtschaft," *Petermanns Mitteilungen,* Vol. 50, 1904, pp. 68–79; 92–95.

affected area is diminished. It is unfortunate, obviously, for us to translate this as "robber industry," as a taking of something to which man has no claim. A better phrase in English is destructive utilization (the word "exploitation," more commonly used, too generally suggests some measure of blame, of unjustified destruction). *Simple Raubwirtschaft* is defined as a process which brings no particular human want or distress, either because the resource is relatively abundant, or because the people move away and thus avoid the results of the shrinkage of the natural resource base. *True* or *characteristic Raubwirtschaft* is defined as depletion which leads to serious human want. It is noted that although primitive people practice sammelwirtschaft, and simple raubwirtschaft, seldom do they experience the want that comes from characteristic raubwirtschaft. They substitute nomadism for the endurance of the serious need which would result if they did not move on. Characteristic raubwirtschaft (destructive use resulting in serious want) is seen as a particular attribute of civilized people.

Here I wish to emphasize certain traits of "civilized people" of the twentieth century. Among them the rate of natural resource depletion has mounted until it greatly exceeds the rate of renewal (as in hunting) or until the fund resource is visibly depleted (in coal mining, for example), and at the same time they have lost much of their mobility. No longer can they solve these problems simply by moving on—either because there is no room (to practice shifting agriculture, for example)[22] or because our institutions make moving about more difficult. True or characteristic raubwirtschaft as defined by Friedrich must be viewed today as a consequence not only of the resource depletion associated with particular modes of life, but also as a result of loss of mobility.

Although Friedrich stresses economic want as the distinctive feature of characteristic raubwirtschaft, he lists many other consequences, such as the destruction of animals of scientific interest, and of others which may prove to be of unsuspected value. We persecute many animals as injurious, he notes, because we lack knowledge of their life-ways. In our short-sighted moral egotism we lightly pass the death sentence.

In turn Friederich discusses mining, agriculture, plants, and animals:

Mining is always raubwirtschaft, as no replacement is possible. Where production is slight, however, only simple raubwirtschaft results. And the want that comes may possibly be delayed, in which case it will bear most heavily on later generations. There is, also, a tendency to exploit the entire earth in the search for minerals: the depletion of local supplies of coal, for example, may be offset by imports from distant lands.

[22] In Southern Rhodesia the pressure of population is used as an argument to convince the natives that they should abandon this type of agriculture. Conversation with Ernest Taylor, agricultural missionary to Southern Rhodesia.

Here we can go well beyond Friedrich: while it is true that there is a vast international trade in minerals, it is clear that nations can not ignore their deficiencies in these or other natural resources. Moreover, no matter how extensively a mineral resource is distributed in a given country (as is coal or gravel in the United States), when the mineral in a restricted part of it is exhausted, some of the consequences of exhaustion of resources are felt in that particular area. And, in this connection, it should be kept in mind that compelling need, contrary to Friedrich, is a gradually evolving state, correlated, in mining, with the rise in physical handicaps in production or of transportation charges from more distant areas. In the depletion of any given resource, there is, in general, no sudden jump from simple to characteristic raubwirtschaft unless the resource is rendered completely useless or destroyed. Pressure of increasing costs is the common accompaniment of the exploitation of a mineral resource, a fact which Friedrich appears to ignore.

Friedrich correlates the geographic distribution of mining with places of more advanced industrial life and the climate most favorable to man; extensions into the tropics by Europeans being exceptions. He sees in mining an activity that not only depletes the resources of an area but also unlooses man's devastative instincts.[23] On the other hand, mining has many times led to enduring settlement.

Turning to soils, Friedrich notes that in western Europe the want consequent upon destructive exploitation of the soil led to knowledge of fertilization, and robber tillage was rooted out. He shows that it is otherwise in colonial lands, where the farmers, like primitive folk, have a surplus of land. First there is a kind of nomadic agriculture. Even with fixed settlement, the accumulated fertility of years suffices. Finally comes near-exhaustion of soil fertility, and want. Then arrives production through fertilization, etc., as a result of which the original fertility may be restored or even surpassed, or unfavorable soils can be made productive. "Destructive exploitation leads of necessity to foresight, to improvements." The apprenticeship, he says, costs not a little, but the improvements are worth it.

Here appears a favorite idea of Friedrich's, and one which places him in a particularly vulnerable position. His sequence, young lands being ruthlessly exploited → lands in want → lands with soils conserved or improved, is a sequence that has been repeated in Europe and elsewhere. But he fails adequately to recognize another sequence, in which depletion leads to further depletion, and in which want leads to further exploitation and eventually,

[23] Mumford expresses a similar view. See Lewis Mumford, *Technics of Civilization,* New York, 1934, pp. 157–158.

perhaps, to complete soil removal. Glendinning has shown this to be the result in the Southern Tennessee Valley.[24]

We may speculate on the reasons for Friedrich's assumption that destructive utilization will commonly lead to a better day. Possibly he may have been moved, quite unconsciously, to defend the Europeans, whom he shows clearly to have been the chief exploiters of the earth; and most certainly he was influenced by the early stabilization of soil fertility in western Europe. We may wonder, however, at his failure to note that southern Europe illustrates the sequence that terminates in permanent impoverishment of the land. He has not profited as much as we might hope from his knowledge of Marsh's *Man and Nature.* In Friedrich's view there is present, however, something of a corrective to the present-day indiscriminate condemnation of all phases of soil depletion.

Turning to plants, Friedrich considers forest exploitation as characteristic of the north temperate zone, particularly the colonial lands such as Canada. As for the primitive people, they clear the land little by little, and soon allow it to revert to timber. Here we meet a false notion which is slowly being displaced by the true one. Such men as Leo Waibel and Dudley Stamp have shown that shifting agriculture, which Friedrich so frequently condones, has been responsible for displacing virgin timber with inferior growth over vast areas.

For plants, as for soils, Friedrich maintains that destruction gives way to foresight: rubber plantations take the place of wild rubber, etc. He also recognizes, although somewhat vaguely, two additional sequences characteristic of biotic resources: (1) destructive exploitation → want → sustained yield of wild forms through management; and (2) destructive exploitation → want → substitution of domestic forms. And he again ignores the possibility that the resource curve instead of being turned up by forethought may continue to drop downward to zero returns, as in places where soil erosion removes the very basis of the original forest. He also overlooks the fact that the shift from wild plants to domestic ones, as in plantations, may shift exploitation from wild plants to the soil itself.

Wild animals are treated in similar fashion. The crowding out of certain wild animals by close settlement is described and noted as inevitable. The regulation of hunting and the substitution of domestic animals for wild ones are recognized as necessary.

In conclusion, the question is asked: Why should this be an age of unprecedented destruction of natural resources? Friedrich is certain that the reason is found in the tempo of our more recent cultural development (a

[24] Robert M. Glendinning: Erosion Conditions in Grainger County, Tennessee, *Econ. Geog.,* Vol. 14, 1938, p. 166.

tempo which increased for at least another quarter century after he published his paper). The peoples of western Europe, to meet their growing needs, have expanded the supply-area from the locality, homeland, and continent to all useful parts of the earth. If a new need appears, a new search quickly develops, and for economy's sake is concentrated on as few points as possible. As a consequence of the want that may ensue, conservative land uses appear. He concludes: "I conceive the Raubwirtschaft of our time as a depletion of land, wild plants, and animals, which will disappear quickly as the culture of northwest Europe is substituted for that of colonial and primitive peoples. Such a substitution will bring an intensive use of earth resources which aims at a firmer and firmer establishment of man on the earth."[25] That such a harmony of uses and earth resources is highly desirable, all would agree. On the other hand, it is surely impossible for anyone who is familiar with the eroded loessial lands of northwestern Mississippi, or the burned and scarred rock hills of north central Ontario, to accept so complacently the damage to resources involved in this process of colonization, or to be so certain that resource depletion is but the forerunner of conservation.

JEAN BRUNHES

Easily accessible to all students of the history of geographical thought, and therefore requiring little elaboration, is the treatment of resource destruction and conservation in Brunhes' *La Géographie Humaine,* first published in France in 1910, and translated in 1920 as *Human Geography.*[26]

In the citations, but particularly in the actual development of the theme, Brunhes shows his very great debt to Friedrich. Indeed a comparison of the two essays leads to the conclusion that one of the principal contributions of the French writer is his service in making available in French (also in English by translation) the main ideas in Friedrich's paper, which, as he avows, was his chief reference, supplemented by his own observations.

Brunhes uses *économie destructive* (translated in *Human Geography* as *destructive exploitation*) to include the whole range from Sammelwirtschaft through characteristic Raubwirtschaft. Friedrich's term, characteristic Raubwirtschaft, is translated in French as *dévastation caractérisée* or *dévastation.* (In *Human Geography,* in turn, it is given as *characteristic devastation* or *devastation.*)

A principal value in Brunhes' treatment is the integration of the facts of destructive utilization in a general classification of the essential facts of

---

[25] Friedrich: *op. cit.,* p. 95.

[26] Jean Brunhes: *La Géographie Humaine,* Paris, 1910; *Human Geography,* New York, 1920.

human geography: (1) facts of unproductive occupation of the soil, houses, and roads; (2) facts of plant and animal conquest; and (3) facts of destructive exploitation. Elsewhere[27] Brunhes notes how the third group may be transformed into the second and first.

In considering the facts of destructive exploitation, Brunhes first treats the principal groups of facts—mineral, plant, and animal. He then passes on to consider the growing reaction against destructive exploitation, the reaction which, in America, goes under the name of "conservation of natural resources." Following are sections which deal in detail with shifting agriculture in the equatorial rain forest as a complex type of plant and animal devastation, and with the mining industries as a phase of resource destruction in middle latitudes.

Brunhes goes much beyond Friedrich, or any of the writers noted, in tracing the new geographical facts created by or dependent on the destructive processes, such (in the case of coal) as the mine, the buildings at the surface, and even cities and industrial zones. We are thus led to see the permanent and semi-permanent results, many of which are beneficial. The facts of destructive occupance are viewed as a part of the whole cultural landscape into which the natural landscape is being transformed.

But Brunhes was a human geographer. The man-made fact and the reaction of that fact on man concerned him most. Like Friedrich, to whom he clearly owed so much, he was completely anthropocentric. In specializing more narrowly than Woeikof, Reclus, and Marsh, these men (Brunhes and Friedrich) have gained a clearer definition of some facts and ideas, but they have thereby weakened their grasp, and perhaps ours, of the total influence of man on nature. Thus does specialization endanger the view of the whole problem.

CONTEMPORARY WRITERS

Brunhes' *Human Geography* is too well known and too easily accessible to require further analysis here. Turning to the literature published since the English translation of his book, we find ourselves dealing with the work of contemporary writers. For obvious reasons, a judicious selection is difficult. As samples of current thought on this theme I have chosen two papers by Carl O. Sauer.[28]

[27] Jean Brunhes and Camille Vallaux: *La géographie de l'histoire,* Paris, 1921, p. 24.

[28] Carl Sauer: Destructive Exploitation in Modern Colonial Expansion, *Proceedings, International Geographical Congress,* 1938, Vol. 2, Sec. 111e, pp. 496–499; and Theme of Plant and Animal Destruction in Economic History, *Journal of Farm Economics,* Vol. 20, 1938, pp. 765–775.

In the first paper he introduces a favorite theme of Friedrich's by posing this question: "Has the process of colonization been beneficent or malignant in its relation to the land?" Does the manner of colonial development represent good or bad stewardship of the land?

We have become habituated to the idea of an expanding world, yet, Sauer maintains, our modern expansion has been effected by permanent impoverishment of the world, and actual consumption of a significant portion of the natural resource capital. The idea of Wirtschaften, [as Friedrich uses it] has given way to money economics. We have excused destructive exploitation as a stage in a normal process which will lead in due time to balanced use and, perhaps, to a permanently higher level of production.

Sauer maintains that impoverishment of the areas colonized by Europeans is the rule, not the exception; he revives the thesis encountered in Woeikof, Friedrich, and others, that the Industrial Revolution and growth of the eighteenth and nineteenth centuries in wealth and population are based on this gutting of colonial lands. This process has involved (1) the extinction, hybridization, or subordination of native stocks and cultures, and (2) diminishment of the productive capacity of the land.

As a consequence of this destruction, economic opportunity has declined in those colonial lands, internal migration is set up from depleted areas to more favored ones, and a back-pressure is checking the inflow of foreign peoples. The days of colonization are over.

The remainder of the first paper relates, in the main, to one form of destruction consequent on commercial exploitation—wastage of soil by improvident use in lands of recent settlement. The principal process involved is held to be erosion. A plea is made that this theme be moved up to the first category of problems before the geographers of the world. From a world-wide study of specific locations should emerge a comparative knowledge of soil erosion.

Sauer opens his paper on plant and animal destruction with a plea for the consideration, when planning for the future, of the human facts of the past, considered as a function both of time and place. In this type of culture history there is "a dominant geographic theme which deals with the growing mastery of man over his environment. Antiphonal thereto is the revenge of an outraged nature on man." Sauer proposes to sketch the dynamics of human history in terms of this antithesis.

The first major step, a prehistoric one, in man's use of nature—plant and animal domestication—is viewed as at first leaving man's symbiotic relations with his environment essentially undisturbed. The first serious discordance, perhaps initiated in Neolithic time, is held to have taken place in the dry interiors of the Old World, where thousands of years of overgrazing

have permanently and sadly diminished their utility. The next major destruction of habitat values is associated with the Mediterranean lands, during the last days of the Roman Empire. In this area, as Friedrich ought surely to have noted, there is little evidence of significant regeneration.

Where Sauer says that with these two major exceptions we know of scarcely any record of destructive exploitation in all of the span of human existence until we enter the period of modern history, we are forced to conclude that he is considering only areas of world-wide significance and that he is referring to characteristic Raubwirtschaft—to resource depletion which leads to serious human want. Surely the *process* of human impairment of critical elements in the natural-resource base has gone on throughout human existence. Prior to modern times, man was generally able, however, to avoid the consequences, either because the net damage was slight or because he could move on to richer areas.

The third and main attack, for the world as a whole, came in the late eighteenth century, when the cumulative destructive effects of European exploitation became marked. In the space of the last century and a half "more damage has been done to the productive capacity of the world than in all of human history preceding." As a consequence, the lands of recent settlement are the worn-out parts of the world (with the exceptions previously noted). Sauer points out, too, the well-known fact that the soil balance of older lands has come to depend on livestock farming. This in turn rests on the importation of cheap feed from colonial lands, where it is produced by methods which exploit the soil.[29]

Three distinct world losses resulting from destructive exploitation are discussed: (1) Certain species and varietal forms have become extinct. The removal of species reduces the possible future range of utility of organic evolution, and the extension of commercial agriculture is causing a rapid extinction of primitive forms. (2) The areal range of useful species has been greatly reduced by local extermination. (3) Soil destruction is widespread—the most serious debit against colonial commercial exploitation. "The cycle of degeneration is very, very difficult to break." How different this is from Friedrich's view, and surely more in harmony with the facts, though Sauer's conclusions reflect, I am convinced, the advantage of living in a colonial land.

The paper closes with a challenge to the optimism that postulates an everlasting sufficiency of natural resources. We are finding our resources declining over large areas and we are finding no place for the people of those

---

[29] Siegfried von Ciriacy-Wantrup (Soil Conservation in European Farm Management, *Jour. of Farm Economics*, Vol. 20, 1938, pp. 86–101) appears to condone this dependence of soil balance in northwest Europe on soil depletion in the colonial lands.

impoverished areas to go. Moreover, even though we have discovered substitutes, we still have the problem of costs imposed by land and sea and climate. The doctrine that a passing frontier of nature can be replaced by a corresponding advance in technology is challenged as simply another phase of the frontiersman's attitude toward his environment.

We may summarize Sauer's second essay by noting these points: the comprehension of the theme of plant-animal-soil destruction in terms of the entire course of human history and for the entire world; the challenge to Friedrich's idea that destruction "normally" leads to improvements; the clear recognition that the destructive hand of man follows a plant group on into its domestic history, thus continuing the impoverishment of man's environment; the emphasis on soil equilibrium obtained in older lands as dependent on the soil destruction in the younger; the challenge to the idea that advances in industrial technology constitute a satisfactory substitute for the age-old expedient of moving on, or of balancing the rate of drain with that of renewal; and the clear presentation of the underlying thesis that these pathological conditions are correlated with social phenomena and must be controlled through changes in social situations.[30]

CONTEMPORARY TRENDS AND PROSPECTS

Herbert Quick, journalist and essayist, wrote in 1925, "George Perkins Marsh died in 1882, after writing some forgotten poems, some equally forgotten scientific books. . . ."[31] Quite the contrary, Marsh's scientific work continues to live on, as we have seen, in that of his followers. Indeed, there is now a strong movement to return directly to his books, to examine his work scientifically,[32] and to make direct use of his writings in popular pub-

[30] It is well to recall that, in this study of the history of a phase of geographic thought, the attention has been focussed on carefully chosen samples. The men whose writings are examined are assumed to have held the ideas they expressed, but not necessarily to have originated them. There is no doubt, indeed, that each man was greatly indebted to his contemporaries and predecessors for basic data and ideas with which to formulate his own world view of this phenomenon—the destruction and conservation of natural resources.

Among the remaining studies which deal in a noteworthy way with the problem as a whole from a world-wide point of view are the following: (1) Nathaniel B. Shaler: *Man and the Earth,* Chautauqua, New York, 1905; (2) R. L. Sherlock: *Man as a Geological Agent,* London, 1922; (3) Camille Vallaux: *Les sciences géographiques,* Paris, 1929, pp. 233–274; (4) Paul B. Sears: *Deserts on the March,* Norman, Okla., 1935; and (5) Phil. Edwin Fels: *Der Mensch als Gestalter der Erde,* Leipzig, 1935 (bibliography, pp. 203–206).

[31] Herbert Quick: *One Man's Life,* Indianapolis, Ind., 1925, p. 201.

[32] Reflected in the article by John Leighly entitled, New Occasions and Duties in Climatology, *Geog. Rev.,* Vol. 29, 1939, pp. 682–683.

lications by including lengthy quotations.[33]

This current trend is a tribute both to Marsh's literary ability and to his broad, penetrating grasp of the problem as a phase of human occupance of North America in particular and of the world in general. In the light of the vigorous growth in the body of objective observation and associated ideas relating to this theme and stemming from Marsh and his contemporaries, we can hardly agree that he is forgotten, nor can we view destruction and conservation of natural resources simply as a practical problem the consideration of which was initiated in the United States by Gifford Pinchot and Theodore Roosevelt during the first two decades of the twentieth century, and furthered the world over by the economic nationalism of the third and fourth decades. We find, instead that we are dealing with a major phase of systematic and regional geography, one that is well rooted in the history of geographic thought.

Although the phenomena of resource destruction, preservation, and melioration have come under the scrutiny of scientifically-minded men for a long time, there are challenging opportunities for further investigation. The passage of time ever brings new tasks to the geographer, who can never count his work as completed so long as the face of the earth continues to change. Moreover, he can now, for the first time in history, carry out his observational studies on a truly world-wide scale. Such investigations of world distributions will involve the identification and understanding of patterns made up of selected items, and of individual regions dominated by resource destruction or conservation.

May I point out, in conclusion, that there is, as yet, no adequate analysis of human and natural causes of resource depletion and restoration, of the processes involved, or of the resulting successions.[34] Surely there is no good reason for continuing to shy away from consideration of processes and sequences in human geography. In brief, the conclusion seems inescapable that the ideology—the framework of ideas—dealing with this theme needs further definition and elaboration. Our ideas should be revised and enlarged as the collection of data goes forward if that body of data is to contribute most effectively to the evolving structure of geographic thought.

University of Wisconsin.
February, 1940.

---

[33] An example is H. S. Person: *Little Waters,* Government Printing Office, Washington, D. C., 1936.

[34] Two valuable statements of this need for geography as a whole are: Derwent Whittlesey: Sequent Occupance, *Annals Assn. Amer. Geog.,* Vol. 19, 1929, pp. 162–165; and Carl Sauer: Cultural Geography, *Encyclopaedia of the Social Sciences,* Vol. 6, 1931, pp. 621–624.

Laterite in Relation to Soils of the Tropics

JAMES THORP AND MARK BALDWIN[1]

In perennially hot and warm regions of low latitudes, commonly known as the tropics and subtropics, soils are fully as varied in character, if not more so, than in the more temperate parts of the world. There is no sharp geographic line of division between soils of tropical regions and those of temperate climates. Aside from regions where subsoils are perpetually frozen, the more easily recognized soil regions are those where broad soil differences correspond roughly to differences in precipitation effectiveness, approximately as defined by Thornthwaite (23) (24). Since precipitation effectiveness within rather broad ranges of "temperature efficiency" controls the general type of vegetation (*e.g.* forest, grass, desert shrub), it is evident that general vegetation zones and soil zones must coincide to a good degree, and it has been demonstrated repeatedly that the influence of vegetation usually is as important as climate in determining the characteristics of soils.

A confusion in terminology and an interest in "laterite" (whatever that is conceived to be by various individuals) considerably beyond the geo-

[1] Soil Scientist, U. S. Dept. Agr., Bur. Plant Ind.; and Senior Soil Scientist, U. S. Dept. Agr., Bur. Plant Ind., respectively.

"The authors are indebted to Dr. Robert L. Pendleton, Soil Technologist and Agriculturist, Department of Agriculture and Fisheries, Thailand (Siam), for much detailed information regarding his observations on the original Buchanan or "ground-water" type of laterite which he has studied in India and Thailand, and for photographs. His observations concerning its genesis, as well as our own, confirm those of Marbut in Brazil and Bennett in Cuba. Pendleton feels very strongly that it would be desirable to apply the name "laterite" only to that material which is essentially like the original laterite of Buchanan and to abandon the use of the word for any of the other soils of the tropics. This proposal has much to recommend it. Pendleton also has given us valuable supplementary information concerning the soil conditions in the Philippines where he studied soils for many years. He has made important contributions to soil science, particularly in the tropics, in the past, and we look forward to reading the results of his researches in Thailand. We do not feel that differences in vocabulary are of fundamental importance so long as everyone understands the meanings of terms used. No one is in a position at the present time to make final decisions as to what system of terminology for soils of the tropics is best. It is hoped that everyone writing on tropical soils will make clear the meaning of terms used so that other students will be in a position to interpret the material in the light of their own experience."

In the text, numbers in parentheses refer to the bibliography on pages 182–183.

graphical importance of this material, has led to fundamental misconceptions that are still held by many. The commonest of these is that a vast blanket of "laterite" or of "lateritic material" covers a large percentage of the area of the warm and hot parts of low-latitude lands. The most fruitful cause of confusion has been the adoption of the name "laterite" by various investigators to cover several sorts of zonal and intrazonal[2] soils. Until recently, chemists and geologists (14) (15) have dominated the field of soil nomenclature in the tropics and much, although by no means all, of their research has been devoted to the study of samples of soil or deeply weathered rock residues that were collected by men who were prospecting for ores of iron, aluminum, nickel, chromium and manganese.[3] Classification of data collected by prospectors and examined and classified by chemists naturally led to misunderstandings concerning the geographical importance of certain types of weathering products and to incomplete information on or misunderstanding of the features of soil profiles which, to the soil morphologist, form the fundamental basis for classification of soils. Features of soil profiles and of weathered parent soil materials by which it is possible to distinguish between zonal and intrazonal soils, apparently were overlooked by some of these investigators, because their interests led them in other directions, and because much of the work was done before soil science had advanced very far.

SOILS OF TROPICAL AND SUBTROPICAL REGIONS

As an example of the complexity of soils of the tropics, 117 soil series composed of 352 local soil types were recognized and mapped in the detailed soil survey of Puerto Rico which has an area of approximately 3400 square miles (21).

The factors of soil development are the same for all parts of the world

---

[2] Zonal soil—Any one of the great groups of soils having well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation.

Intrazonal soil—Any of the great groups of soils with more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief, parent material, or age over the normal effect of the climate and vegetation. Each group of these soils may be found associated with two or more of the zonal groups.

Yearbook of Agriculture, 1938, Soils and Men, pp. 1180 and 1170, respectively; U. S. Dept. Agr., 1938. Washington, D. C.

See Table 2 for characteristics, environing conditions, and uses of tropical soils of both groups.

[3] Many samples examined or reported by Harassowitz (9) fall in this category. He was influenced by the work of Bauer (3) who had a strong influence on the nomenclature of tropical soils.

except for the permanently frozen lands and the lands where rain practically never falls. These factors are: climate, biological activity, slope, parent material or parent rock and time (12). One has only to remember the variability of each factor to realize that the possible combinations of factors and their variations is almost infinite, and that the resulting recognizable soil differences will be very large indeed; hence the necessity for classification.

Many soil scientists distinguish between "soil parent material" and "parent rock," while others consider that all superficial weathered rock material is a part of the soil and that "parent soil material" and "parent rock" should be synonymous terms. Although both viewpoints can be logically defended, a large number of scientists prefer the former; and "parent soil material," a product of rock weathering, will be distinguished in this paper from the practically unweathered parent rock.

Soil parent materials develop through chemical and physical weathering of rocks. It is certain that chemical weathering is more important than physical weathering in subhumid, humid and wet[4] (after Thornthwaite) tropical and mesothermal climates, than physical weathering, and it certainly is very important also in dryer and cooler climates. Hydrolysis of primary minerals, simple solution, carbonation and oxidation and reduction operate to convert hard rocks and sediments into mixtures of clays and coarser fragments of greatly varying composition (7). The great mass of field evidence points to the conclusion that rock weathering proceeds more rapidly in hot than in mesothermal climates where precipitation effectiveness is the same; and a great mass of chemical evidence indicates that certain end-products of weathering, as the sesquioxides of iron, aluminum, and chromium and various forms of manganese dioxide are produced in a much larger proportion than in mesothermal and microthermal climates (17). Since other weathering products are common to both tropical and cooler climates it is evident that the range in chemical characteristics of soil parent materials in the tropics is considerably greater. In general, rock weathering has extended to far greater depths in the humid and wet tropics and subtropics than under similar moisture conditions in mesothermal and microthermal climates.

Those who have attempted to correlate zonal soil groups with climate long ago discovered that effectiveness of climate in itself depends on temperature and on the amount of water that passes into and through the soil material. It was soon learned that a mere measurement of precipitation is no measure of the effectiveness of moisture. This ultimately leads to the

---

[4] Definitions of these terms may be found in the *Yearbook of Agriculture, 1938, Soils and Men,* pp. 1165, U. S. Dept. Agr., Wash., D. C.

concept of precipitation effectiveness and in turn to Thornthwaite's P: E index (See Table 1).

TABLE 1

An Outline of Thornthwaite's Climatic Classes[5]

Eight chief climates	*P:E index*	*Vegetation type*
With adequate temperature efficiency		
A Wet	128 and above	Rain forest
B Humid	64–127	Forest
C Subhumid	32–63	Grassland
D Semiarid	16–31	Steppe
E Desert	Less than 16	Desert
With inadequate temperature efficiency		
D′		Taiga
E′		Tundra
F′		Perpetual frost (little or no veg.)

Temperature efficiency provinces are classified as follows:

Temperature class	T: E Index
A′ Tropical	128 and above
B′ Mesothermal	64–127
C′ Microthermal	32–63
D′ Taiga	16–31
E′ Tundra	1–15
	0

Seasonal moisture distribution

r	moisture abundant at all seasons	
s	" deficient in summer	wet-dry and moist-dry climates
w	" " " winter	
w′	" " " spring	
d	" " at all seasons	

Combinations may be made of the five precipitation-effectiveness classes with the first three temperature classes for further subdivision of the chief climates, and these, in turn, may be further subdivided by adding symbols representing temperature subprovinces (not listed above) and seasonal moisture distribution. The following climatic classes seem to have an important bearing on the formation of different great soil groups of the tropics: AA′r, wet tropical; BA′r, humid tropical; BA′w, humid, winter-dry, tropical; CA′s, subhumid subtropical, summer-dry; CA′w, subhumid tropical and subtropical, winter-dry; DA′d, semiarid, tropical and subtropical; EA′d, arid, tropical and subtropical.

[5] "The Climates of North America according to a New Classification," Geog. Rev. 21 (23).

There is a gradual increase in the proportion of warm (especially red) hues in zonal soils, whether they be in desert or humid regions, from microthermal to tropical climates. This generalization is true of only a small part of the intrazonal soils.

ZONAL SOILS

Zonal soils have already been defined. Since they are always naturally well drained, they normally occur on convex or sloping land or on flat areas where subsoil drainage is hastened by porous underlying material.

Red and Yellow Podzolic[6] soils are among the important zonal soils of tropical and subtropical regions. Frequently they are closely associated under the same climatic conditions, but where this is true the Yellow Podzolic soils either lie on somewhat smoother land or are developed from materials very low in iron content. These soils extend well into the mesothermal climatic regions. Yellow Podzolic soils are most widely developed under tropical, subtropical, and warm mesothermal climates with well-distributed rainfall (AA′r, BA′r and BB′r) and Red Podzolic soils are most widely developed under tropical, subtropical and warm mesothermal climates with a dry season, usually in winter (AA′w, BA′w, and BB′w).

As a class the Red and Yellow Podzolic soils are very erodible and in many parts of the southeastern United States, southern China and in many tropical regions as well, erosion has truncated them to such an extent that they are no longer useful for cultivated crops.

Reddish-Brown and Yellowish-Brown Lateritic soils are widely distributed in wet and humid tropical regions both where the rainfall is well distributed and where it is seasonal. Yellowish-Brown Lateritic soils are more common under wet-dry humid and subhumid climates than in permanently wet climates, while the Reddish-Brown Lateritic soils are somewhat more common where rainfall is higher and more evenly distributed.

These two soils have been variously called "laterite," "lateritic soils," "red loams" (22) and "friable clays" (4). The Reddish-Brown and Yellowish-Brown Lateritic soils are valued for agricultural purposes because of their excellent tilth. Water passes through them rather readily so that it has been found profitable to irrigate them where the rainfall is not very high or where there is a dry season. Soils of the Reddish-Brown and Yellowish-Brown Lateritic groups in Puerto Rico, Cuba, Central America, and the Hawaiian Islands are used for a large variety of crops and in the last location are very highly valued for sugar cane production where they can

[6] Called simply Red and Yellow soils by Marbut (16). Soil names used in this paper follow the *Yearbook of Agriculture, 1938* (26).

Plates illustrating these and other soils discussed in the text are to be found at the end of the paper.

be irrigated and heavily fertilized. Unirrigated soils of these groups in the Hawaiian Islands are used for growing the famous Hawaiian pineapples. In the East Indies and in Africa they are valued for rubber production. Although some of these soils are moderately erodible, their productivity is not appreciably impaired by sheet erosion, as has been pointed out by Bennett and Allison.[7]

"Laterite soils" as defined by Marbut (22) and as used in the nomenclature of the U. S. Department of Agriculture (26) are quite different from the original materials described and named by Buchanan as laterite. A discussion concerning Buchanan's laterite follows in later pages. The Laterite soils are well drained and very old and they usually lie on undulating or gently rolling land. One of the best known of these soils is the Nipe series of Cuba and Puerto Rico and it is known that similar soils occur elsewhere in the tropics. The Nipe series was called a ferruginous laterite by Marbut to distinguish it from those Laterite soils that have a lower percentage of iron sesquioxide and a higher content of aluminum sesquioxide. Some of the Laterite soils such as the Nipe series are sufficiently high in iron content to be suitable for use as iron ore and many deposits have been mined for this purpose and others contain workable quantities of bauxite, chromium and manganese. Soils of very similar character are known to exist on several different kinds of rock, such as basalt, limestone, and purplish-red sandstones and shales. *We wish to emphasize as forcibly as possible at this point that the Laterite soils have a different origin and are entirely different in morphology from the original laterite of Buchanan.* The chief reasons for the confusion of terms are the fact that Buchanan did not give a full account of the materials which overlay his laterite; and in the past the concepts of laterite and of the process of laterization have been stretched to cover all red or reddish soils of tropical regions which have a set of chemical characteristics that fit in well with hypotheses concerning the development of the soils of the tropics (high-alumina, low-silica content). Fox recently has shown (8) that Buchanan's laterite does not conform chemically to these hypotheses.

In passing from subhumid to semiarid and arid regions in the tropics, one finds a sequence of soils the characteristics of which parallel those of soils in similar areas of precipitation effectiveness in mesothermal and microthermal climates. The well-drained normal soils in these situations consist, in part at least, of Reddish Prairie soils, Reddish Chestnut soils, Reddish Brown soils, and Red Desert soils. The first two normally have grassy vegetation and dark-colored surface soils (See Table 2).

---

[7] *Soils of Cuba*, page 27: "Freshly exposed subsoil (of Matanzas soils) is as productive as the top soil."

TABLE 2

GENERAL CHARACTERISTICS OF TROPICAL SOILS AND THEIR ENVIRONS*

Zonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Red Desert	Light reddish-brown surface soil, brownish-red or red, heavier subsoil closely underlain by calcareous material. Alkaline reaction.	Desert plants, mostly grasses and shrubs. Acacia-desert grass savanna (20).	Tropical and warm-mesothermal; arid EA′d, EB′d.	Good to imperfect.	Grazing in large units. Intensively farmed where irrigated.
Reddish Brown	Reddish-brown soil grading into red or dull-red heavier subsoil and then into whitish calcareous material, either cemented or soft. Neutral to alkaline reaction.	Tall bunch grass and shrubs.	Tropical and warm-mesothermal; semiarid DA′d, DA′w, DB′d.	Good	Grazing in large units. Small specialized farms where irrigated.
Reddish Chestnut	Dark reddish-brown in surface soil. Heavier and reddish-brown or red below. Lime accumulation at 2 feet or more depth. Neutral to alkaline reaction.	Mixed grasses and shrubs. Savanna.	Tropical and warm-mesothermal; semiarid to subhumid. CA′w, CA′r, CB′w, CB′r, CB′d.	Good	Cereal grains and cotton. Excellent grazing in large units.
Reddish Prairie	Dark-brown or reddish-brown soil grading through reddish-brown heavier subsoil to parent material. Moderately acid.	Tall-grass prairie. Acacia and tall-grass savanna.	Tropical and warm-mesothermal; subhumid to humid. CA′r, CB′r.	Good	Wheat, oats, corn, cotton, hay, forage crops.
Yellow Podzolic	Thin, dark-colored organic covering over pale yellowish-gray leached eluvial layer 6 inches to 3 feet thick over heavy yellow illuvial horizon over yellow, red, and gray mottled acid parent material. Streaks of ground-water laterite in places.	Coniferous, mixed coniferous and deciduous and mixed deciduous and evergreen broadleafed forests.	Tropical and mesothermal; humid to wet. AA′r, BA′r, BB′r (and same as Red Podzolic).	Good to imperfect.	Small to medium-sized farms. Subsistence crops, cotton, tobacco, peanuts, fruit and vegetables, rice, and sugar cane. Infertile but very productive when fertilized and well managed. Forests.

TABLE 2.—GENERAL CHARACTERISTICS OF TROPICAL SOILS AND THEIR ENVIRONS.*—(*Continued*)

Zonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Red Podzolic	Thin organic layer over yellowish-brown or grayish-brown leached and eluviated surface soil over deep-red illuvial horizon of heavier texture. Parent material frequently reticulately mottled red, yellow and gray. Acid.	Deciduous and some evergreen broad-leafed forest. Conifers. Burned-over areas covered with tall coarse grasses (cogonales).	Tropical and mesothermal; humid to wet. AA'w, BA'w, BB'w, (and same as Yellow Podzolic).	Good	Small to medium-sized farms with cotton, tobacco, subsistence crops and some sugar cane. Infertile, but very responsive to fertilization. Much waste land and forest.
Yellowish-Brown Lateritic	Brown friable clays and clay loams over yellowish-brown friable clays with high percent colloids. Acid to neutral.	Evergreen and deciduous broad-leafed trees. Some cogonales.	Tropical and mesothermal; humid, wet-dry, subhumid. BA'w, BA'r (?), BB'w, BB'r(?), CB'r(?).	Good	Small farm units, with subsistence and special crops and forest. Sugar cane. Yields medium to high where irrigated and fertilized.
Reddish-Brown Lateritic	Reddish-brown or dark reddish-brown friable, granular clayey soil over deep-red friable and granular clay. Deep subsoil, normally red or yellow but is reticulately mottled in places.	Tropical rain forest to edge of savanna. Some cogonales.	Tropical and mesothermal; wet to humid. AB'r, BA'r, AA'r, BB'r. Some in wet-dry areas (?).	Good	Small farm units with subsistence crops. Plantations of citrus, pineapples, sugar cane, rubber, some forest. Productive with fertilization and more so with irrigation.

TABLE 2.—GENERAL CHARACTERISTICS OF TROPICAL SOILS AND THEIR ENVIRONS.*—(*Continued*)

Zonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Laterite soils	Red-brown clayey surface soil. Red, deep clay illuvial layer. Red or reticulately mottled parent material. Very deeply weathered.	Tropical rain forest to savanna. Some cogonales.	Tropical; wet or wet-dry. AA′r, BA′w, BA′r.	Good	Very infertile. Small subsistence farms with some specialization on plantations. Much waste land and forest. Mined for iron and aluminum in places.

INTRAZONAL SOILS

Intrazonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Solonchak	Gray thin salty crust on surface, fine granular mulch just below, and grayish friable salty soil below. Salts may be concentrated above or below.	Sparse growth of halophytic grasses, shrubs, and some trees.	Tropical and mesothermal; semiarid and arid. EA′, EB′, DA′, DB′, CA′, CB′.	Poor or imperfect.	Some grazing. Much waste land. Some reclaimed. Used for producing salt and saltpeter in places.
Solonetz	Very thin to a few inches of friable surface soil underlain by dark, hard columnar layer, usually highly alkaline.	Halophytic plants and thin stand of others.	Tropical and mesothermal; semiarid; CA′, CB′, BA′, DB′, EA′, EB′.	Imperfect	Same as associated normal soils. Yields medium to low.
Wiesenboden	Dark-brown or black soil grading, at a depth of 1 or 2 feet, into grayish and rust-mottled soil.	Grasses and sedges.	Tropical and mesothermal; humid to subhumid. BA′, BB′, CA′, CB′.	Poor	Same as associated normal soils where artificially drained. Undrained soils in many places are used for rice.

TABLE 2.—GENERAL CHARACTERISTICS OF TROPICAL SOILS AND THEIR ENVIRONS.*—(*Continued*)

Intrazonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Bog	Brown, dark-brown, or black peat or muck over brown peaty material.	Swamp forest or sedges and grasses.	Tropical and mesothermal; wet to semiarid. AA′, AB′, BA′, BB′, CA′, CB′, DA′, DB′.	Very poor.	Forest and charcoal.
Half-Bog	Dark-brown or black peaty material over grayish and rust-mottled mineral soil.	Do.	Do.	Do.	Do.
Planosols	Strongly leached surface soils over compact or cemented claypan or hardpan. Some have normal A and B horizons above the claypan or hardpan —a secondary profile. Parent materials mottled.	Grass, forest or savanna.	Do.	Imperfect or poor internally and externally (flattish land).	Crops, pasture and forest varying with regions. Low to medium yields of crops.
Ground-Water Podzols	Organic mat over very thin acid humus, over whitish-gray leached layer up to 2 or 3 feet thick, over brown or very dark-brown cemented hardpan or ortstein. Grayish deep substrata.	Forest of various types.	Tropical and mesothermal; wet to humid. AA′, AB′, BA′, BB′.	Do.	Forest. Some regional crops and pasture. Low yields.
Rice Paddy Soils	(See text.)				

TABLE 2.—General Characteristics of Tropical Soils and Their Environs.*—(*Continued*)

INTRAZONAL SOILS

Intrazonal soils	*Profile*	*Native vegetation*	*Climate*	*Natural drainage*	*Use*
Ground-Water Laterite	(See text of paper)				
Vlei and Shachiang soils	(See text of paper)				
Braunerde	(See text of paper)				
Rendzina	(See text of paper)				
AZONAL SOILS					
Lithosols	(See text of paper)				
Alluvial soils	(See text of paper)				
Dry sands	(See text of paper)				

* These data are largely from the *1938 Yearbook of Agriculture—Soils and Men.*

A few small areas of very dark-colored soils in the subhumid and semiarid portions of Puerto Rico have been called tropical Chernozems (21) although it is not certain yet as to whether this small area represents any important soil group in the tropics as a whole. These tropical Chernozems are almost as dark colored as the northern Chernozems and are somewhat reddish in color. In addition, they have heavy subsoil horizons which correspond to the heavy subsoils of the Reddish Chestnut soils.

Reddish grassland and desert soils extend from the tropics and subtropics well into the mesothermal climatic regions, although they do not everywhere reach to the coolest portions. Climatic conditions are approximately as follows:

Soils	*Climates*
Reddish Prairie	CA′r, CB′r
Reddish Chestnut	CA′w, CB′w
Reddish Brown	DA′d, DA′w, DB′d
Red Desert	EA′d, EB′d

The Regur or black cotton soil (Malwa series) of India is very dark gray or nearly black at the surface, low in organic matter, and grades to lighter shades of gray and an accumulation of lime concretions at a depth of about 1 meter. So far as our information goes, only those portions of it that are adjacent to fairly steep slopes have any tint of red color. This seems to indicate that much of the Regur may be an intrazonal rather than a zonal soil.

In those portions of the Netherlands Indies with subhumid and semiarid climates and marked dry seasons, Mohr (19) describes somewhat similar black and dark-brown soils, which have been developed from all sorts of materials.

In the leeward portions of the Philippines, where wet and dry seasons are sharply alternating, we have seen black soils without lime accumulation, and Brambila (5) has recently reported similar soils in Mexico. Proper classification awaits further study.

INTRAZONAL SOILS

A definition for intrazonal soils has already been given. Intrazonal soils of the tropics as elsewhere, occur in close association with zonal soils but differ from them in several fundamental respects.

Soils developed under periodically or permanently high water table.

A large proportion of intrazonal soils develop under a permanent or periodic excess of moisture. It is very usual to find well-drained normal

zonal soils lying on gentle slopes or on convex hilltops adjacent to large flat areas of intrazonal soils where drainage has been impeded because of the lack of relief. Much of the rain water that falls on flat areas remains in place and saturates the soil instead of running off. The degree and character of profile development depends partly on the amount and distribution of rainfall, the effectiveness of which is modified by the rate of evaporation, and on the length of time during which the soil material has been exposed to soil-forming processes. On low alluvial terraces that have only recently been free of floods and deposition of silt, profile development is not as extreme as on older alluvial terraces, and these in turn may not be as extreme as on old undissected peneplains that have been in place for tens of thousands of years.

If the land is flat, water from rainstorms collects on the surface and saturates the subsoil and parent material. If the flat areas are broad and if the climate is of the continuously wet type (AA'r), soils of these positions will be permanently waterlogged. Soils in such positions usually are dark gray or bluish gray in color and sticky and plastic in consistence. Such soils in marshy areas are known as Wiesenboden and in forested areas as Half-Bog soils. If the parent materials and soils in such a position are more rapidly pervious so that there is a constant lateral movement of water through them, they will eventually become strongly bleached (podzolized) and greatly impoverished of plant nutrients. Claypans, silt pans and hardpans are common in these soils which have recently been called Planosols (26).

Rice paddy soils, which have been artificially flooded for a considerable portion of each year, perhaps over long periods of time, are among the most important of all the soils of tropical as well as of temperate regions. Because these soils have usually been flooded artificially, and much altered by man's activity, profile types among them vary considerably. Some profiles show pronounced evidences of ground-water podzolization, both in upper horizons and in more porous portions of the substrata; on the other hand some profiles show little or no evidence of podzolization but are of fairly uniform texture and structure throughout. While some of them are neutral or alkaline in reaction, most are moderately to strongly acid (to as much as pH 4.5).

The more strongly acid paddy soils are the ones in which ground-water podzolization is most noticeable. From field observations it appears that the soils of paddy fields in the tropics and subtropics are gradually trending first toward the Planosols and finally toward the Ground-Water or Buchanan Laterite. Deeper strata are becoming reticulately mottled and surface horizons gradually are becoming light gray in color. Places were

observed in China (25), about 120 miles southwest of Nanking, where horizons that had many of the morphological characteristics of true (Buchanan) laterite had developed beneath the plow layer of soil. The fact that this peculiar type of horizon was found parallel to the surface on a series of artificially leveled paddy fields indicates that it was formed in place after the land was leveled for the purpose of raising rice. But this is not especially surprising when one considers that these soils are continuously flooded for more than half of each year, so that soil-forming processes must be very greatly accelerated.

Where the climate is of the wet-dry type (BA′w), as is true of a very large total area of tropical and subtropical regions, the soils of flat areas are completely waterlogged during the wet season when the water table remains at or very near the surface, and very dry in the dry season. During the wet season, decomposition products of the remains of the last season's leaves and dead plants are carried into the soil water and assist in further chemical weathering of soil materials. Iron is reduced and made soluble, especially near the surface where there is an abundance of organic matter, and is ready to move in solution with the ground water.

At the end of the rainy season the accumulated water slowly drains away laterally or evaporates, and its level in the soil becomes lower and lower, fluctuating somewhat with the last rains of the rainy season. As the water recedes and air takes its place, some of the dissolved iron is precipitated in the subsoil as ferric oxide. For some reason not as yet fully understood, this precipitation takes place partly around centers of accumulation to form rounded concretions and partly parallel to soil cracks and root holes. Between the iron streaks thus formed the clays that remain behind become light colored and eventually almost white. This irregular deposition of iron results in the formation of reticulated streaks of reddish-brown and yellowish-brown iron-rich soil material in subsoil horizons, and black, brown and red pellets or concretions that are cemented by iron or manganese compounds or by silica, or by combinations of all of these. The upper part of the soil to a depth ranging from a few inches to 2 or 3 feet, gradually loses its iron compounds and some of its clay and takes on a light-gray or brownish-gray color. The process by which this bleaching is brought about has been called a form of podzolization. Apparently, it is a part of the same process which Mohr calls lixiviation (19). If this process continues for a very long time, the iron streaks in the reticulately mottled horizons of the subsoil become more and more pronounced, and the surface horizon lighter and lighter colored. Eventually, the material of the reticulately mottled horizons will harden to stone if exposed a short time to the air.

For a long time in India, Malaya, and Africa, natives have dug pits in

this material while it is still moist and soft, have cut it into blocks which are trimmed and allowed to harden into stone, and have used them for building material. When Buchanan (6) found the natives of India making building stone in this way, he described the process and called the material "laterite" (*later*, Latin for brick). Many of the temples and other buildings of ancient cities such as Ankor Wat of French Indo-China and many temples in Siam are constructed of a kind of laterite very much like that described in Buchanan's notes (20). Unfortunately, Buchanan gave us no information concerning the material that overlay his laterite deposits and this lack of information has led to many misconceptions concerning its mode of formation. By the time Marbut visited the valley of the Amazon (13) the term laterite had already been applied by different scientists to almost the entire range of strongly developed red or reddish soils of the tropics. In order to avoid further confusion, Marbut used the term "Ground-Water Laterite"[8] to set apart materials like the original laterite of Buchanan, which he found along the high terraces of the Amazon. Apparently, he was the first, in the western hemisphere at least, to recognize that Ground-Water Laterite owes its characteristics to the process of ground-water podzolization. The lower part of the reticulated layer he considered to be parent soil material rather than a part of the true solum, and many of his colleagues have followed his example in this.

Much of Buchanan's type of laterite lies on peneplains that are considered by geologists to be of Pliocene age. The largest of these that have been studied are on the plains of Siam, where in many places the eluvial and illuvial horizons remain without truncation. The parent soil material here is developed principally from purplish-red sandstones and shales. The soils are exceedingly poor and support only a scrubby tree growth and a few rice fields in the wetter depressions. Where the laterite horizon has been exposed by erosion of the bleached horizon above it, it hardens in the sun to form a stony surface that will support practically no vegetation. The present authors—and Pendleton in Thailand—have studied these so-called "laterite crusts" in the field and *we are convinced that erosion of superficial layers and exposure of the laterite horizon is the true explanation of the origin of the much-discussed laterite crusts.* Various authors have given various other explanations, among which the most common is the hypothesis that iron in solution migrates to the surface by capillary action during the dry season and is left as a crust when water evaporates.

Remnants of laterite of the Buchanan type were observed to underlie

[8] Marbut began using this term some time after his expedition to the Amazon valley, but in his lectures in 1928 he referred to the Amazon formations of this type as Ground-Water Laterite.

Red and Yellow Podzolic soils in the deeper subsoils on Pliocene terraces and straths in central and southern China (25) and it was quite obvious that these materials originally were developed under poor drainage conditions. From the evidence at hand it seems almost certain that a wet-dry type of climate is necessary for the formation of Ground-Water Laterite.

The "laterite" cappings of hills or mesas which are now found in central India and in the desert parts of Australia are remnants of former peneplains, in the soils of which the laterites had developed, and they represent former climatic and drainage conditions quite different from those which now obtain in those places.

Buchanan's laterite, then, in reality represents a kind of Planosol development. It is the ultimate result or final end product of very long weathering in warm climates under the influence of ground water. To have these conditions prevail for a sufficiently long time, the land surface must have been a peneplain for a very long time; thus the country must have been static tectonically, and there must have been no deposition of fresh material from floods or from volcanic or other wind-borne materials. For these reasons there are practically no laterites of this type in all the Philippines.

Buchanan's laterite is known to have been developed from a large variety of parent materials and rocks, including granite, basalt, gneiss, schist-phyllite, old mixed alluvial terrace deposits, purplish-red sandstones and shales, both non-calcareous and calcareous, limestones, volcanic ash and tuff, gabbro and serpentine. And when the laterite of the world has been fully studied, no doubt other rocks will also be included. But such rocks as quartzite and siliceous sandstones and shales can hardly be expected to weather to form this material.

The occurrence of Bog and Half-Bog soils and forested Planosols on nearly level areas that are geologically younger than areas of Buchanan's laterite seems to indicate that they will eventually be converted to the latter if they remain in place long enough.

Ground-Water Podzols of the tropics usually develop on very sandy parent materials with a high content of quartz sand and a very low content of clay and of clay-forming minerals. They strongly resemble the Ground-Water Podzols of southern United States.

In Africa certain black waxy hydromorphic soils of moist depressions have been described. Many of these soils have subsoil horizons that contain calcium carbonate in the form of concretions or in some cases massive concretionary layers. These soils are known as Vlei[9] soils. From descriptions they ap-

[9] Vlei or vley [flā] is an Afrikaans word—probably a corruption of the Dutch *vallei* meaning valley (Webster). The word is commonly applied in Africa to low-lying land where water collects during the rainy season. The word has crept into soil

pear to be essentially the same as the Shachiang soils (25) of the North China Plain, where mesothermal, wet-dry climatic conditions prevail. This part of China is characterized by humid summers with periods of flood during which the Shachiang soils are covered by water; during the long winter-dry season the excess water gradually seeps away or is evaporated. In these soils limestone concretions vary from a fraction of an inch in diameter to large rounded masses several inches in diameter and to massive limestone bodies several feet thick. It is quite evident that in both the Vlei and Shachiang soils the characteristics depend upon the presence of a large amount of water during a part of each year and a long dry period in between. Soils of the central portion of the Indo-Gangetic Plain would probably fall close to this group.

Peat and muck are widespread in tropical regions, especially along seacoasts. So far as we know, nearly all of these organic soils are acid in reaction. The degree of development of different types of hydromorphic soils depends partly upon the amount of water present, upon the length of time it is present and the temperature regime, as well as upon the periodicity of the rainfall.

Halomorphic soils and planosols of grasslands

In the dryer portions of the tropics, soils that contain more or less soluble salts (halomorphic soils) are common. These might be roughly classified as Solonetz and Solonchak and are not greatly different from their counterparts in cooler climates. In addition to these there are some Planosols associated with the Reddish Prairie, Reddish Chestnut and Reddish Brown soils. These soils resemble the normal soils with which they are associated to a certain extent but all of them are characterized by heavier horizons (claypans) above the lime accumulation of the normal soils. These claypans are sticky and plastic when wet and hard and stiff when dry. Many of them are suitable for the production of cultivated crops, especially sugarcane, when they are irrigated and when the claypan horizons are periodically broken by deep knifing operations.

Rendzinas and shallow soils

Rendzinas are dark-colored granular soils, high in organic content, that develop on soft calcareous materials. They are common in many parts of the tropics and occur under all sorts of climatic conditions except possibly in the desert, where vegetation is not sufficient to produce an abundance of organic matter. They are suitable for a wide variety of crops and are highly prized where they are deep enough to permit the growth of roots.

literature and now is in fairly common use. Among others, Shantz and Marbut (22) used the term in 1923.

On the steeper slopes of humid and wet tropical regions, there are many varieties of shallow soils some of which, because of perennial rejuvenation by a rapid geological erosion, have characteristics not greatly differing from the Gray-Brown Podzolic soils and the Braunerde of cooler climates.

AZONAL SOILS

Azonal soils occur under all sorts of climates. Azonal soils of the tropics include Lithosols which consist essentially of rock fragments mixed with a small proportion of fine materials; Alluvial soils, which are composed of fresh alluvial deposits; and Dry Sands. The Alluvial soils of the tropics are among the most important to agriculture since a larger proportion of them are fertile. It is very common to find neutral Alluvial soils, high in fertility and organic matter and very productive when cultivated, lying adjacent to Laterite soils and Ground-Water Laterites that are either very infertile or can be made productive only by heavy fertilization. A large proportion of the agricultural population of tropical and subtropical India and of South America gains its livelihood from the rich Alluvial soils.

THE CATENA CONCEPT

A sequence of zonal, intrazonal and azonal soils all of which are developed from the same kind of parent rock within one soil zone is known as a catena. In the Yearbook of Agriculture, the catena has been defined as "A group of soils within one zonal region developed from similar parent material but differing in characteristics of the solum owing to differences in relief (slope) or drainage. From the Latin for chain." As originally defined by Milne (18), the catena is based on the parent rock rather than on the parent soil material and it is believed that this interpretation is better since it obviates the necessity of argument as to what is soil and to what is soil material. The catena concept brings out very well the importance of the effect of relief on soil profile development. It is very useful as a means for classifying soils for mapping purposes and for remembering individual soil series. It is obvious, however, that not all soil associations are catenas, since it is not uncommon for variations in parent rock to correspond to variations in local relief. In such cases, closely associated soil types must be considered as forming non-catenary complexes rather than catenas.

VERTICAL ZONALITY OF SOILS

Within tropical regions there is a very rapid change in climate as one ascends from the lowlands to the higher levels of the mountains. Where the mountains reach above the truly tropical climates, one finds a rapid succession of soils much like those of the mesothermal and microthermal climates.

If we were to go into the characteristics of these soils we should be largely repeating details concerning soils of middle and high latitudes that are already familiar to most geographers.

* * * * * *

It is certain that the groups listed will not cover all tropical soils, but it is believed that they will include well over three-fourths of the total area, and possibly even more. It is interesting to note in this connection that probably half or more of the world's population gains its living from the valley lands of the world where recent alluvium or only relatively young terrace and local alluvial materials are dominant. In the tropics one finds native agriculture concentrated on (a) rich alluvial deposits; (b) volcanic ash, (c) soils under subhumid climates, or (d) on soils on steep slopes where erosion has been very active so that soils have been kept sufficiently youthful to have a reasonably high fertility. Senile soils, such as the soils in which there are laterite horizons, usually have an extremely low inherent fertility and are almost totally useless for agriculture. The value of senile soils, particularly lateritic ones, for forestry is also low.

Plantation types of agriculture in the tropics have been able to use many of the different kinds of red and yellow tropical soils. Such soils are obviously not rich in nutrients, but Hevea rubber and tea do not need very rich soils. The use of commercial fertilizers and green manure crops makes big differences in yields. Primitive caingin (milpa) or stick-planting agriculture, which depends upon the regrowth of forest to kill the weeds that infest the clearings, is confined to lands on which forest will readily grow again, such as on young soils on steeper slopes. Irrigation agriculture and rice growing, for the most part dependent upon irrigation, can be extended to smooth uplands of the semiarid areas as well as to the flood plains. Fortunately for the peoples of the tropics, rice can be grown on relatively infertile soils so long as water is available for irrigation; and if lime, green manures, and night soil can be added, the yields can be greatly increased.

CONCLUSIONS

Buchanan's laterite does not, by any means, dominate the tropics but occurs even there only in limited areas, in association with fully as large a variety of great soil groups as occur in the temperate zones.

Buchanan's laterite is a soil horizon which, where undisturbed or uneroded, lies well below the surface of the land. This horizon may be illuvial, and certainly is accretionary in character. The soil is hydromorphic in character and represents the extreme of development as a result of the action of a high but periodically fluctuating water table. The evidence is that laterite horizons are most likely to form where there are at least fairly well defined

wet and dry seasons, even though some laterites might possibly occur where the present rainfall is relatively evenly distributed throughout the year. As in arid central India and in desert Australia, laterite now exists where nearly desert conditions prevail, but in these places geological evidence is conclusive that the material is fossil, representing the effects of a water table in a peneplain and a previously much more humid environmental condition.

REFERENCES

(1) Baldwin, Mark. 1938. Soils of the Hawaiian islands. *In* Soils and Men, Yearbook of Agriculture, U. S. Dept. Agr.

(2) Baldwin, Mark, Kellogg, Charles E. and Thorp, James. 1938. Soil classification. *In* Soils and Men, Yearbook of Agriculture, U. S. Dept. Agr.

(3) Bauer, Max H. 1898. Ueber die nature des laterits. Petermann Mitth. 44, 280–283.

(4) Bennett, H. H. and Allison, R. V. 1928. The soils of Cuba. Tropical Plant Research Foundation, Wash., D. C.

(5) Brambila, M. 1939. The tepetate soils of Mexico. Proceedings of the Sixth Pacific Science Congress. Berkeley, Calif.

(6) Buchanan, F. 1807. Journey from Madras through Mysore, Canara and Malabar. Geol. Mag., Vol. 11, p. 436.

(7) Byers. H. G., Kellogg, Charles E., Anderson, M. S. and Thorp, James. 1938. Formation of soil. *In* Soils and Men, 1938 Yearbook of Agriculture, U. S. Dept. Agr.

(8) Fox, Cyril S. April, 1936. Buchanan's laterite of Malabar and Canara: India, Geol. Surv. Records, V. 69, pt. 4, pp. 389–442.

(9) Harassowitz, H. 1930. Soils of tropical regions and laterite; from E. Blanck's Handbook der Bodenkunde.

(10) Hardy, F. and Croucher, H. H. Studies in West Indian soils. (VI) 1933. Some soil types of Jamaica. (IX) 1935. Some soil types of British Honduras, Central America; College of Agriculture, Trinidad, B. W. I.

(11) James, P. E. 1935. An outline of geography. Ginn and Co.

(12) Kellogg, Charles E. 1936. Development and significance of the great soil groups of the United States. U. S. Dept. Agr. Misc. Pub. No. 229.

(13) Marbut, C. F. and Manifold, C. B. 1926. The soils of the Amazon basin in relation to agricultural possibilities. Geog. Review, Vol. XVI, No. 3.

(14) Marbut, C. F. 1928. Soils, their genesis, classification and development. Lectures VIII to X (mimeographed); Graduate School, U. S. Dept. Agr.

(15) ——————. 1932. Morphology of laterites. Proc. and Papers, Int. Congr. Soil Science, Commission V, pp. 72–80. Leningrad-Moscow, U.S.S.R.

(16) ——————. 1935. Soils of the United States. *In* U. S. Dept. Agr. Atlas of American Agriculture, Pt. 3, Advance Sheets No. 8, 98 pp. illus.

(17) Miller, Willet G. 1917. Lateritic ore deposits, with comments on the nature of laterites in general. Report of the Ontario Bureau of Mines, Vol. XXVI, Pt. 1.

(18) Milne, G., *et al.* 1936. A provisional soil map of East Africa (Kenya, Uganda, Tanganyika, and Zanzibar) with explanatory memoir. London.

(19) Mohr, E. C. J. 1930. Tropical soil-forming processes and the development of tropical soils, especially in Java and Sumatra; Eng. trans. by R. L. Pendleton. Nat. Geol. Surv. China.

(20) Pendleton, Robt. L. 1939. Soils of Siam and Philippines—discussion. Summary to be published in Proceedings of Sixth Pacific Science Cong., Berkeley, Calif.

(21) Roberts, R. C. and party. 1939. (In preparation for publication.) Soil survey of Puerto Rico. U. S. Dept. Agr., Bur. Plant Industry, Series 1936.

(22) Shantz, H. L. and Marbut, C. F. 1923. The vegetation and soils of Africa. Am. Geog. Soc. Research, Series 13.

(23) Thornthwaite, C. W. 1931. The climates of North America according to a new classification. Geog. Rev. 21: 633–655.

(24) ————. 1933. The climates of the earth. Geog. Rev. 23: 433–440, illus.

(25) Thorp, James. 1936. Geography of the soils of China. Pp. 555. Nat. Geol. Survey of China, Nanking (now located at Chungking).

(26) U. S. Dept. of Agriculture. 1938. Soils and men; Yearbook of Agr.

(27) Vageler, P. W. E. 1933. An introduction to tropical soils; trans. by H. Greene. Macmillan & Co., Ltd., London.

Washington, D. C.,
January, 1940.

Photo No. 206–3. J.T.

PLATE 1A.— Red Podzolic soil developed from reticulately mottled clays in southern Anhwei Province, China. The protruding layer is "laterite" of the Buchanan or ground-water variety.

Photo No. 205–2. J.T.

Plate 1B.—Reticulately mottled clays developed from alluvial deposits of Pliocene or Pleistocene age, Hangchow, China. These clays have a morphology similar to Buchanan's laterite but they do not turn to stone when dried. They are parent materials of Red and Yellow Podzolic soils.

Photo No. 184–3. J.T.

PLATE 2A.—Friable, Reddish-Brown Lateritic soil near Kunming (Yünnanfu), China, showing remnants of dolomitic limestone.

Photo No. 185–2. J.T.

PLATE 2B.—Reddish-Brown Lateritic soil (red loam) near Kunming, China, developed from dolomitic limestone residuum. The grass-covered hills in the background were formerly covered by mixed deciduous and evergreen broadleafed forest.

Photo No. 206–5. J.T.

PLATE 3A.—Silty claypan (S) underlying thin iron hardpan (H) in an abandoned and eroded rice paddy, 120 miles southwest of Nanking, China. These horizons developed after the paddy was built.

Photo No. 59–5. J.T.

PLATE 3B.—Laterite of Buchanan type underlying Red Podzolic soils, Nanchang (Kiangsi), China. Parent rock is schist phyllite.

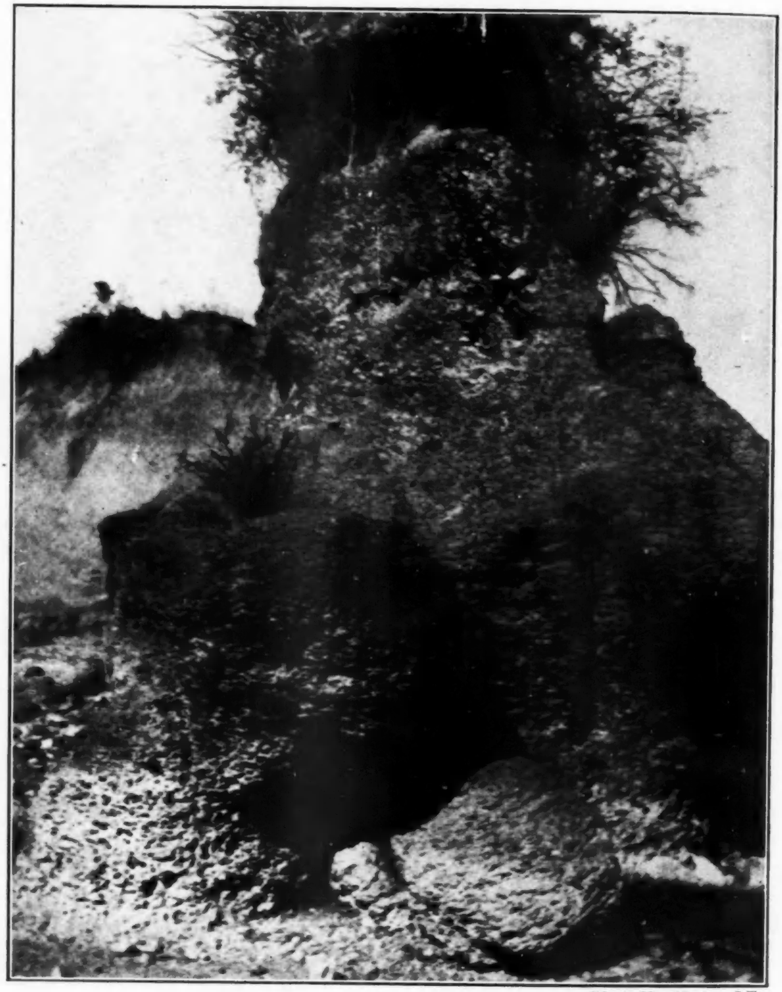

Photo No. 65–8. J.T.

PLATE 3C.—Laterite of the Buchanan type on Pliocene (?) terraces at the edge of Tungting lake, Yochow (Hunan), China.

Photo No. 532–8. R.L.P.

Plate 4A.—Laterite exposed by nearly complete erosion of the surface soil. The "B" or laterite horizon is not quite flat—the higher portions here appear black, the lower are still covered with soil and dry grass, for this photo was taken during the dry season. Looking down a gentle slope toward the edge of a convex body of red clay ("red loam") weathered from basic igneous rock. Chantaburi, southeast Siam.

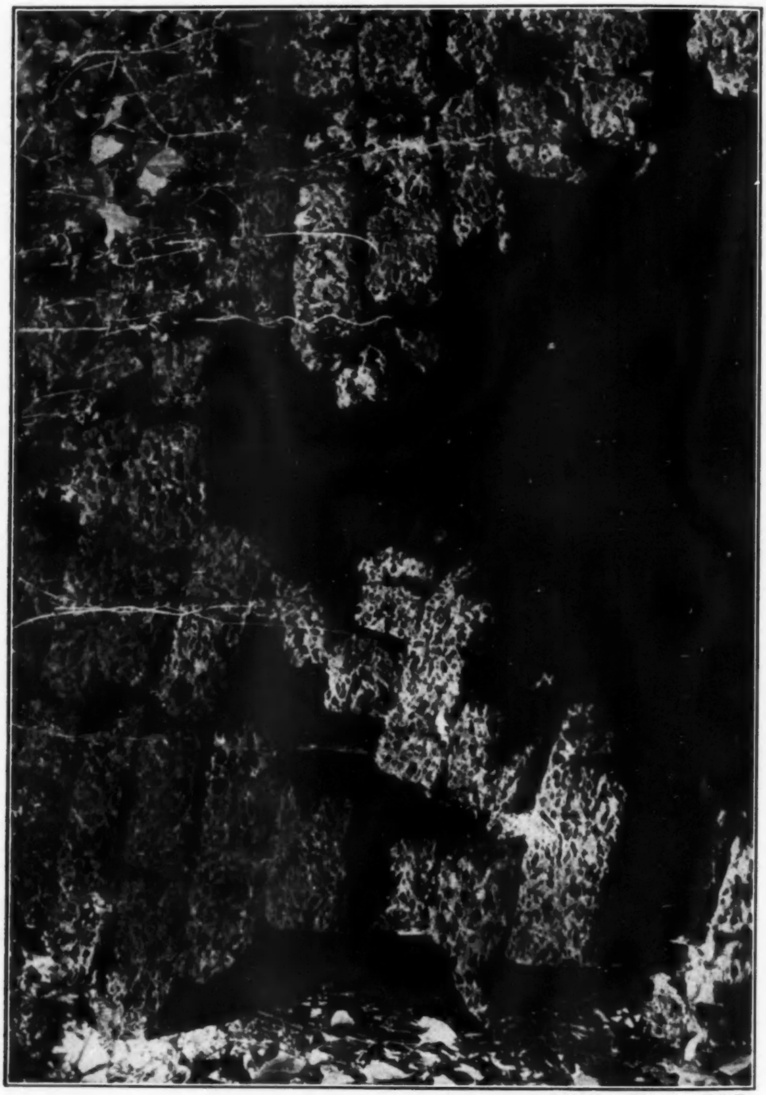

Photo No. 567–10. R.L.P.

PLATE 4B.—Looking into a vaulted passage of an ancient building constructed of laterite. Built about the 12th century, many centuries before arch construction was known in Siam, this ruin near Sawankolok, northern Siam, shows well the vesicular nature of this extensively used building material and how it was used to span corridors.

Photo No. 590–1. R.L.P.

PLATE 5A.—Wall of carefully fitted laterite blocks surrounding an ancient Siamese temple. Probably the circular holes were for insertion of hooks used in carrying and placing the blocks. This laterite is of a denser, unusually compact form—in fact, part of it is pisolitic rather than vesicular in nature. The posts, sill and lintel of the doorway are of a dark purplish-red sandsone. About 12th century, Ban Kanpong, northeast Siam.

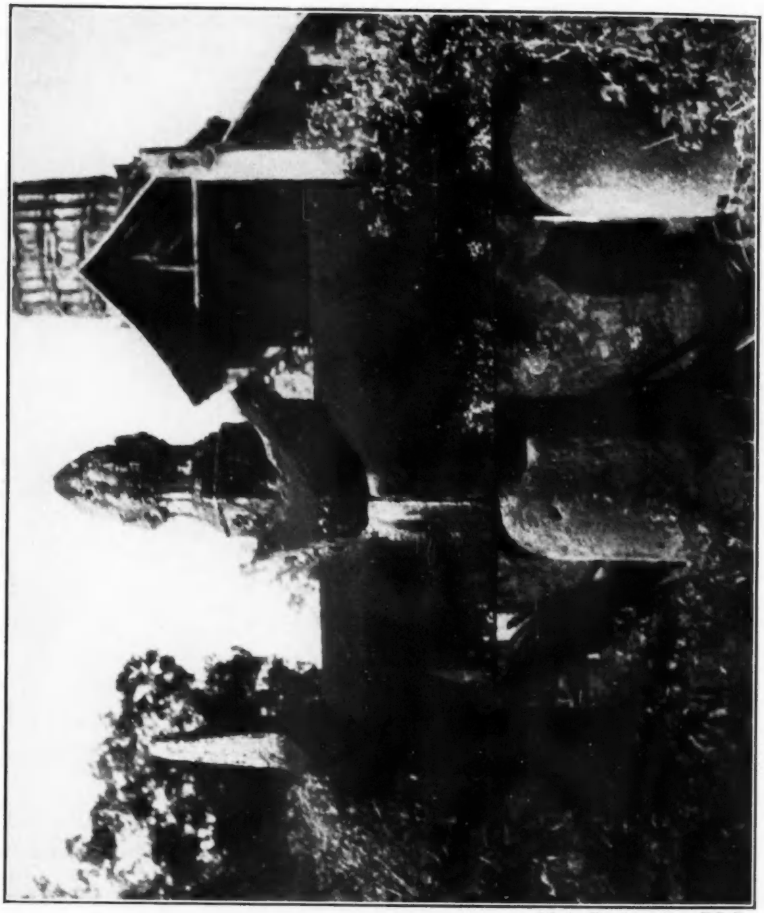

Photo No. 566-10. R.L.P.

PLATE 5B.—Ancient temple gateway constructed of unusually large blocks of laterite. This laterite is stronger because a less porous form. The total height of the columns is not known, for much river silt and debris has accumulated in this 12th century ruin. The modern temporary bamboo and grass roof in the background shelters the very large image of Buddha. Sawankolok, northern Siam.

Jill

After 100 Years of Vacillation Cleveland Solves Its River Problem

C. LANGDON WHITE

Nearly every important settlement on the Great Lakes grew up about the mouth of a river or creek, where early shipping could proceed upstream and get protection from strong winds and waves during loading and unloading. When the harbors were well or even only fairly well endowed by Nature for transshipment and manufacture, great cities (ports) grew up and prospered. Those harbors which were poorly endowed, on the other hand, invariably languished. Had it not been for its harbor possibilities, Cleveland's site might even now be in farm land.

Located strategically at the outlet of an important natural lowland route from the Pennsylvania coal fields to Lake Erie, Cleveland has been able to handle efficiently and easily Lake Superior iron ore southbound and Appalachian coal northbound (Fig. 1). It has become one of the country's leading ports, handling as much tonnage in seven months as do Boston, Baltimore or Philadelphia in twelve. Moreover, at the mouth of the Cuyahoga is the biggest cut in the shale cliffs which closely approach the southern periphery of Lake Erie from Ohio's Vermilion River on the west to Dunkirk, New York, on the east. Hence here the steel rail meets the water's edge with comparative ease (Fig. 2).

While Cleveland cannot match Erie or Duluth in natural harbor nor Chicago in strategic position with respect to existing rail or future inland waterway systems for vessels and barges of moderate draft, it is able to assemble coal, iron ore, and limestone easily and economically and is a major iron and steel center (Fig. 1).[1]

THE HARBORS

As is the case with most lake cities, Cleveland's port consists of an outer and an inner harbor (Fig. 3). The outer harbor is the lake-front area protected by breakwaters and is given over almost entirely to commerce. The inner harbor consists of (1) the Cuyahoga River, devoted to industry, and (2) the mile of the Old River (where the Cuyahoga assumes the shape of an oxbow) which runs westward and is well suited for handling ore, coal, sand,

[1] Charles Langdon White, "Location Factors in the Iron and Steel Industry of Cleveland, Ohio," *Denison University Bulletin, Journal of the Scientific Laboratories*, Vol. XXIV, April, 1929, pp. 81–97.

FIG. 1.—Cleveland's strategic location with respect to iron ore, coal (close stipples show the Appalachian Field; heavy black stripes coking coal; open stipples non-available coal), and fluxing limestone. In addition to the Lake Huron side of the Lower Peninsula of Michigan, which is outstanding in limestone production, Kelley's Island and Marblehead in Ohio are important sources of metallurgical stone. Cities invariably grow up where bulk is broken. It is true that Cleveland's "basic commodity is transportation." Scale of map approximately 1 : 18,500,000. (Map by C. Langdon White and George Primmer. Courtesy of *The Geographical Review*.)

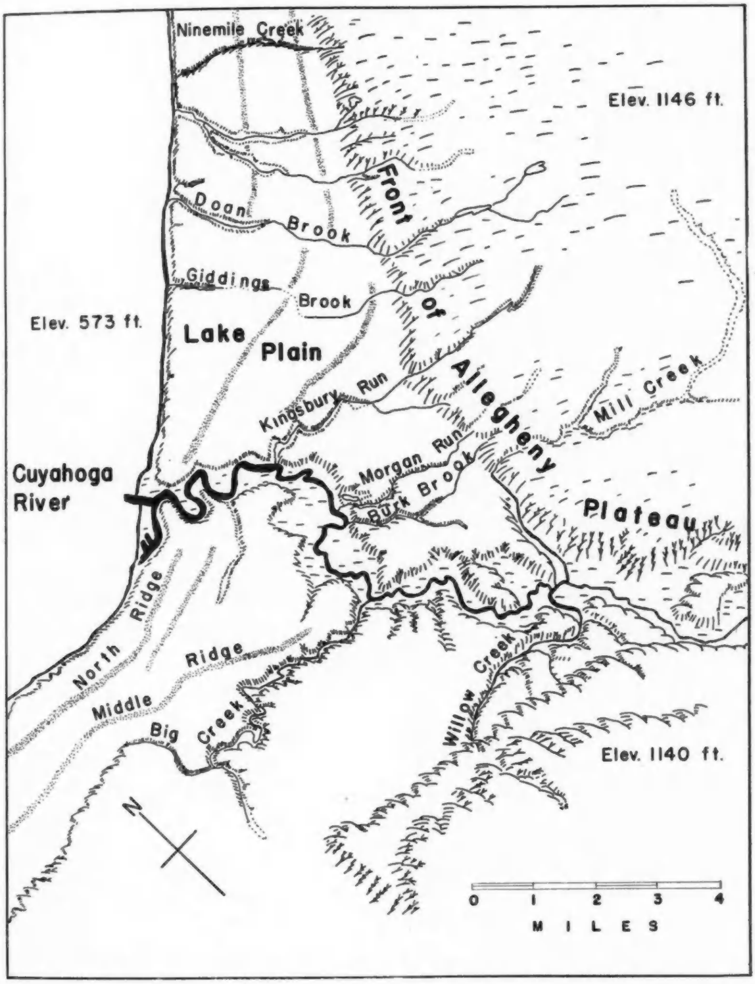

FIG. 2.—Physiographic diagram of the site of Cleveland, Ohio. Note the Flats (the lower Cuyahoga Valley), the lake plain, the ravines, and the Allegheny Plateau. The Cuyahoga River divides the city into the west side and the east side—a significant division in the economic, social and political life of the city. (Map drawn by R. B. Frost and Edwin J. Foscue.)

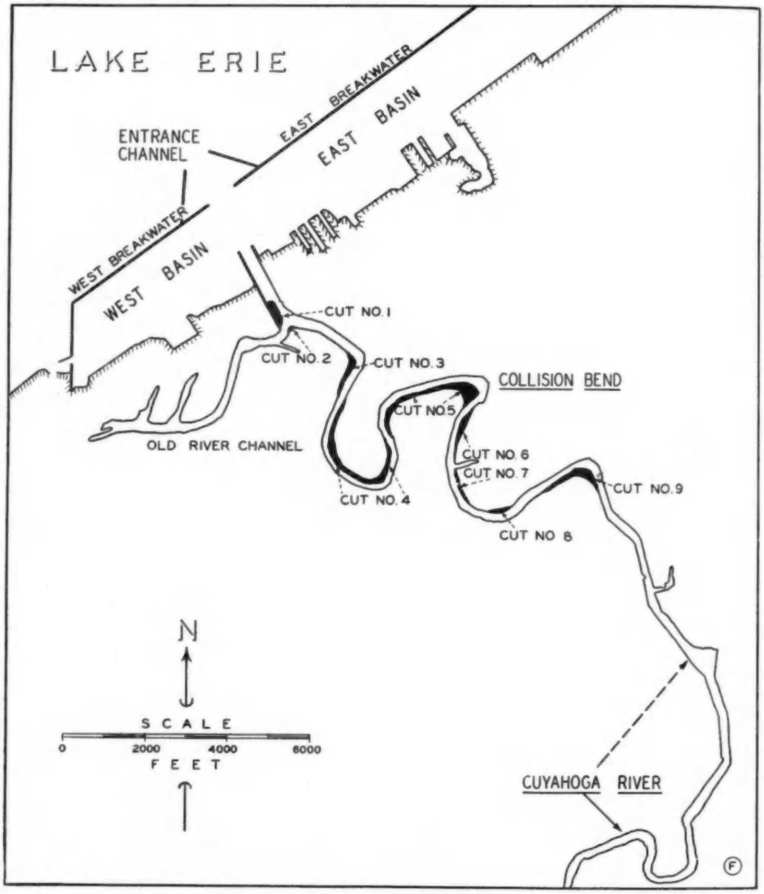

FIG. 3.—Cleveland's harbors: (1) the outer (lake) or commercial harbor comprising the West and East basins, and (2) the inner (river) or industrial harbor. From its mouth the Cuyahoga is navigable for about 5.1 miles. Note the cuts at the worst bends—especially that at Collision Bend. The largest lake carriers can now reach the steel mills. (Map by C. Langdon White and Edwin J. Foscue.)

and gravel and gives the city a good place for a ship yard (Fig. 3). This separation of the commercial and industrial harbors is in line with the most modern practice according to R. S. MacElwee, one of the nation's outstanding port authorities.[2]

[2] R. S. MacElwee, *Cleveland's Lake Front and Port Problem, Preliminary Report,* 1927.

The absence of iron and steel mills from the lake front of this city which ranks fifth among United States metallurgical centers in steel ingot capacity, promptly arouses one's curiosity. It is explainable by the following circumstances:

(1) For more than 80 years, the lower river was Cleveland's sole harbor, and industrial plants located here to benefit from the only transportation available; only here could vessels get protection to load and unload (Fig. 5).

(2) As the outer harbor was developed it was designed to serve the needs of commerce and the city rightfully insists on reserving it for that purpose. Moreover, the cost of city lake-front land is prohibitive to an industry requiring *immense* tracts of *cheap* land.

(3) The strip of land from the lake to the high bank on the south is too narrow to sustain an industry demanding such large tracts of land (Fig. 2).

The Cuyahoga Valley is, therefore, the only water-front location available to heavy industry. The portion of the river so used is the lower 5.1 miles (Fig. 3). Dredging is carried on each year in an effort to maintain a depth of 22 to 25 feet; formerly, before this operation began in the spring, it was not uncommon for the depth to vary from 7 to 14 feet. By dredging to a depth of 22 to 25 feet, the project depth (allowing for silting) can now be kept at 21 feet.

INDUSTRIES LOCATED IN THE RIVER HARBOR

The industries that have located along the river are those engaged in the manufacture of iron and steel, plaster and cement, paint and varnish, and chemicals. Most of these, but especially those engaged in the manufacture of iron and steel, use large quantities of low value material and hence benefit from economical water transport. Furthermore, nearly all dispose of some industrial waste in the river, and use huge quantities of industrial water. (It is estimated that the iron and steel industry in the Flats[3] utilizes more than twice as much water in a 24-hour period as the metropolitan area with its million inhabitants.) Petroleum refining also is located in the valley but has little connection with the river; it is there primarily because of an early start; Cleveland was the home of John D. Rockefeller and of the original Standard Oil Company. That the Cuyahoga and the iron and steel industry are inseparably linked is indicated by the fact that more than 90 per cent of the tonnage inbound (and the bulk of the tonnage is inbound) consists of iron ore, limestone, and scrap. Usually only those industries handling raw materials that are bulky or heavy in proportion to their value benefit from location on a navigable river.

[3] Cleveland has four distinct surface features—the lake plain, the ravines, the heights (a part of the Allegheny Plateau) and the Flats—the valley of the Cuyahoga where navigable and industrialized (Fig. 2).

Fig. 4.—Aerial mosaic map of the Cuyahoga River, photographed in 1931. It presents convincing proof that the Indian word "Cayhaga" meaning "crooked" was an ideal descriptive term. Note the industrial life in the Flats and the numerous bridges over the river. (Courtesy of Cleveland Chamber of Commerce.)

In 1938, the largest continuous wide-strip mill in the world was built in the upper Cuyahoga Valley 1½ miles above the present head of navigation. Here the river is shallow and meanders badly. Army engineers are studying the advisability of extending the navigation channel that far, the accomplishment of which would, according to experts, mean one million tons of new river freight per year.

THE CUYAHOGA: RIVER AND VALLEY

The Cuyahoga River and Valley constitute topographic feature number one in the Cleveland area (Fig. 2). The valley is about one-half mile wide and is entrenched 60 to 125 feet into the glacial drift and delta sand that fill the old pre-glacial valley (Fig. 2).

When Moses Cleaveland and his party landed at the mouth of the river, they found the entrance obstructed, even to the boats of their day, by a sand bar. At ordinary stages there were only about three feet of water.[4] Spring floods usually destroyed the bar, but summer and autumn storms invariably created a new one. Boats, therefore, had to anchor outside and unload into scows and lighters. Early in the nineteenth century man began to eliminate the obstacle by constricting the channel with jetties. In 1910–11 dredging was begun—an operation which for the first time enabled boats to navigate the river as far as the present head of navigation.

The Cuyahoga is reputed to be the crookedest important stream flowing into the Great Lakes (Fig. 4). So greatly does its shape differ from that of the orthodox river that it caused early surveyors considerable trouble; their maps actually represented the source as near Akron and many years were to pass before the true course of the river became known.[5]

Between the Cuyahoga's debouchure and the Jefferson Street Bridge (a distance of approximately two miles), there is a total of 855 degrees of curvature or 2⅜ circles. A navigator must keep a definite landmark in mind or completely lose his sense of direction (Fig. 4). Nearly 200 years ago Amerindians paddling along its kinky course found it a problem and applied to it the term "cuyhaga," which means "crooked." For nearly 100 years the white man has labored against its sinuosity.

In this paper only the navigable part of the course—the 5.1 miles from the mouth to the Otis Steel Company Plant is considered (Fig. 3).

OBSTACLES PRESENTED BY THE CUYAHOGA RIVER

The Cuyahoga is today both Cleveland's biggest asset and its biggest physical obstacle. So annoying and costly have been the problems it pre-

[4] *Port of Cleveland*, Lake Series No. 5, War Department, Corps of Engineers, U. S. Army and U. S. Shipping Board, 1932, p. 2.

[5] Actually it rises in the highlands of Geauga County within 15 miles of the lake shore but then flows 60 miles southward and southwestward away from the lake.

sents that Clevelanders sometimes wonder whether the Cuyahoga or any large river in the heart of a great city is the benefit that it was in earlier days.

During the past four decades the problems presented by the river became intensified, for as Cleveland grew so did lake vessels (Figs. 5 and 6). The river was so narrow and tortuous, the bends so abrupt, and the bridges so numerous and some so low that navigation was slow and difficult (Fig. 6). Thus bulk freighters required about five hours to travel from the Cuyahoga's mouth to the upper steel plants, a distance of about five miles. Moreover, the boats had to be towed, both loaded and light and in the latter case stern first. Those bound upstream required two tugs. Vessels were prohibited from using their own propellers because these stirred up mud and encouraged shoaling. Towage costs approximated $400.00 for the round trip. Other operating expenses and overhead amounted to approximately $100.00 per hour, which meant that the actual cost of the round trip varied from $1200.00 to $1500.00. This additional cost of limestone, iron ore and scrap was obviously a definite charge against the products of Cleveland's steel mills and to that extent affected their markets. This was significant because competition in the iron and steel industry has been extremely keen.

The river's curvature also has made it difficult for vessels exceeding 480 feet in length to reach the head of navigation. They could have gotten farther upstream but the danger and delay were so great as to discourage the trip if other business was available. Collision Bend was a "thing of terror by day and by night" (Fig. 3) and Irishtown and Wheeling bends were only slightly less menacing. Hence it is little wonder that vessel owners and captains testified repeatedly that they preferred to take a cargo to any port on the Great Lakes than to dock on the Cuyahoga in Cleveland.

The river bisects the city and lies on the floor of a deep valley. A tangling web of bridges (25 if the Old River be included) was spun across the stream in its 5-mile navigable stretch (Fig. 4). Several, long and costly, span the valley at the high level of the commercial and residential portion of the city. The others cross the channel at the level of the Flats. More than half the total number actually obstructed navigation. Some "seem to have been built in complete disregard of the requirements of lake vessels of even moderate size."[6] Most objectionable in delaying river traffic are the railroad bridges since they interlock with adjoining track and often remain closed when they should be raised promptly. Sometimes trains actually stand on the bridges or are maneuvered back and forth over them, and this takes place on a stream that must handle on an average six vessels a day—three heavy and three light. What this can mean was driven home re-

[6] *Report of Charles Keller to E. J. Kulas, Chairman, River and Harbor Committee of the Cleveland Chamber of Commerce*, October, 1929, p. 7.

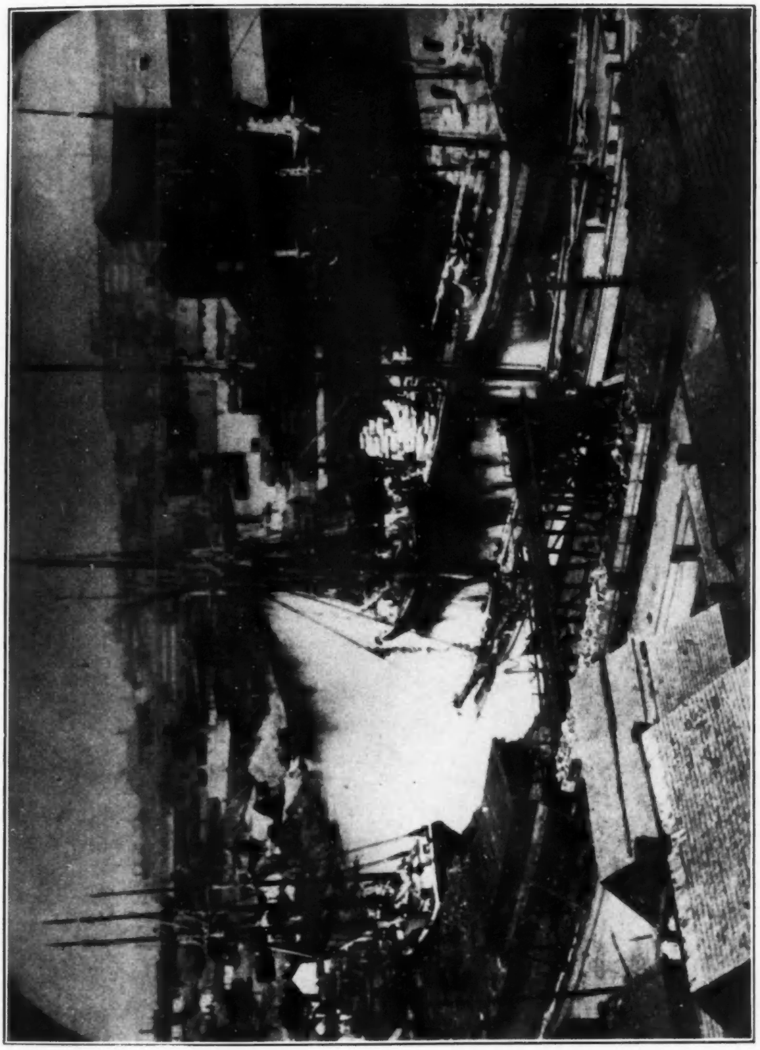

FIG. 5.—View along the Cuyahoga River in 1874. There is no mistaking the river's importance in the economic life of early Cleveland. It is a far cry, however, from the small craft of that day to the lake carrier of 1940. (Courtesy of *The Cleveland Plain Dealer.*)

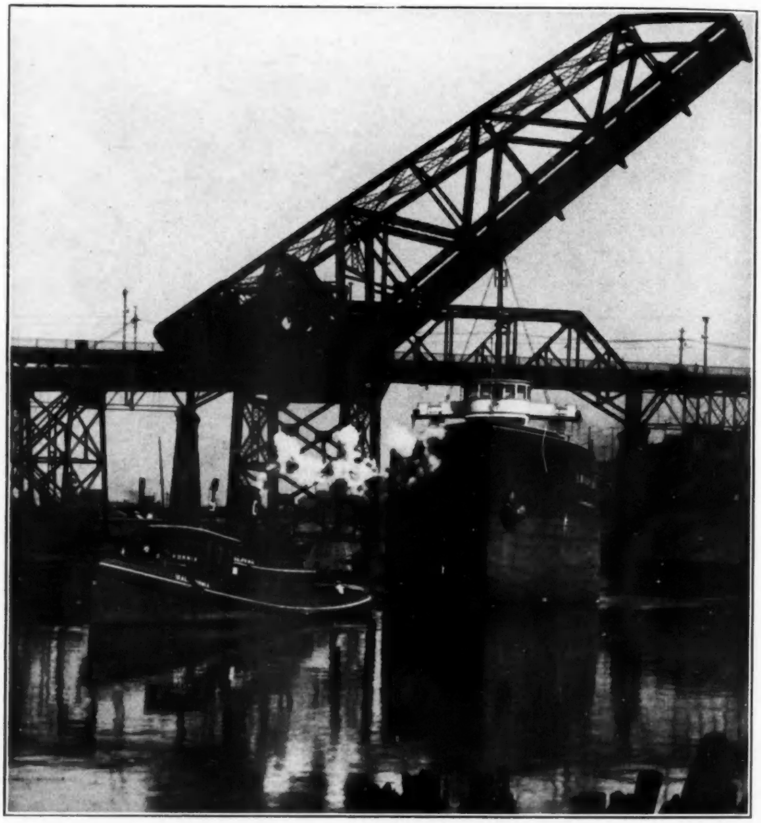

FIG. 6.—The Cuyahoga has been unduly restrictive in its influence on navigation: narrow course, sharp curves, shoals and numerous and some exceedingly low bridges all conspired to make a trip to the upstream steel mills a hazardous and costly venture. (Courtesy of *The Cleveland Plain Dealer.*)

cently when one old bridge closed the channel for 24 hours delaying the delivery of 30,000 tons of ore and costing one ore dock at least $15,000 in extra handling charges.[7] Obstruction to river movement by bridges "constitutes a crime against modern shipping" according to a leading authority on Great Lakes transportation.[8] The bridges that most handicapped river

[7] D. B. Gillies, "The River—A Problem and An Asset," *The Clevelander,* February, 1938, p. 5.

[8] L. C. Sabin, "Essential Features of a Lake Port," *Canadian Engineer,* Vol. 53, November 29, 1927, p. 563.

transportation have now been removed and replaced by modern efficient structures.

Another problem created by the curves in the river is the dearth of river frontage for wharfage. This is consequent upon the fact that the boats have until recently required the entire width of the Cuyahoga to get around the bends. The river long ago should have been dredged from dock to dock.

Still another problem has been and still is the scarcity of suitable raw water for industrial use. While the public water supply is distributed to all parts of the metropolitan area, where it is sold at the flat rate of eight cents per thousand gallons, a reasonable rate for potable water, it is nevertheless too expensive for large industrial users such as iron and steel plants. The Cuyahoga is accordingly the major source of industrial water and while the quantity is unlimited within the navigable area, the quality is poor: it is polluted and attains very high temperatures, this latter being consequent upon repeated use for cooling purposes.

THE RIVER PROBLEM

Cleveland's big problem with respect to the Cuyahoga has been so to improve conditions of traffic that the city would be on a parity with competitive ports by enabling the largest lake freighters to reach the upper steel plants and a short distance beyond. This was imperative if the city were to retain present mills and attract new ones.

Who's task—the city's or the Federal Government's—was the improvement of the river? Until recently the Federal Government's policy on the Great Lakes was to improve only outer harbors. Improving inner or river harbors was considered the responsibility of the cities. Yet even in this respect the Government was not consistent because rivers were dredged at Duluth, Chicago and Toledo.[9]

CONSEQUENCES OF CLEVELAND'S FAILURE TO IMPROVE THE CUYAHOGA

Cleveland, however, did little to improve the river and accordingly suffered irreparably. Despite the fact that industrial and engineering leaders made exhaustive studies, published reports, and made recommendations, and that in 1930 bonds totalling $3,250,000 were voted for improving the river, nothing of importance was done until the late 1930's. In fact eight different plans were drawn up between 1912 and 1937. Up to 1929 only cut-offs were considered. Engineers estimate that 65 years ago the cost of *straightening* the river would have been about $350,000; the recent easing of bends without any straightening together with the demolition and rebuilding of old, narrow bridges approximated $11,000,000.[10] This was due largely

[9] L. C. Sabin, *op. cit.*, p. 563.

[10] "Cleveland Gets to Its Crooked River Job," *Engineering News-Record*, October 13, 1938.

to "expensive rearrangement of railroad and industrial facilities"—obviously potent deterrent factors. The following are consequences of the city's protracted procrastination:

(1) Engineers estimate that for every ten years improvement was delayed, the community suffered an economic loss equal to the cost of straightening the river.

(2) Land values so increased during the past 65 years and especially during the 1920's that any radical river-straightening project other than cutting back sharp bends (Fig. 3) was economically impossible.

(3) Some iron and steel companies that wanted to locate in Cleveland did not do so and some already there deserted, because of water transport difficulties.

(4) Large boats (those exceeding 480 feet in length) were unable to navigate the Cuyahoga up to the steel plants. A vessel of 10,000 tons dragged on the bottom. Had this situation continued, Cleveland mills would have been so handicapped by high-cost ore delivery that they would either have had to migrate or cater exclusively to the local market. The large carriers are much more economical to operate than the small ones. For instance, there is a saving of at least six cents per ton when ore is shipped in a vessel 600 feet long having a capacity of 12,000 tons rather than in one 400 feet long having a capacity of 6,000 tons. To this saving must be added about two cents to cover the added cost of unloading the smaller boat.[11] As early as 1913 only 55 per cent of the lake carriers could be towed around the abrupt bends and through the narrow channel of the lower river; by 1924 this percentage had been reduced to 32 and in 1938 it was even lower. Fewer small boats are thus available now than in the past, and the time was not far away, had it not been for the recent improvements in the river, when the number of vessels small enough to navigate the Cuyahoga would have been so restricted as to make difficult the matter of supplying the iron and steel mills without a substantial extra charge. Cargo boats are now being built very large—two recently completed being 635 feet long.

(5) Much valuable time was lost by vessels. The time required to deliver ore to the American Steel and Wire Company's Central Furnace, unload, take on coal, and depart has been thirty hours.[12] The same thing is done at the plant of the National Tube Company at Lorain in eleven hours. At Conneaut, boats until recently were actually unloaded in the time required to get to the head of navigation on the Cuyahoga. A saving of only five

[11] *Report of Special Committee of the Cleveland Chamber of Commerce*, July, 1913, p. 16. Corroborated December, 1939, by Mr. L. C. Sabin, Vice President of the Lake Carriers Association.

[12] Not every vessel, of course, that unloads ore in Cleveland returns up the lakes with coal.

hours on each of thirty trips during the season of navigation, would amount to nearly seven days or ample time for one additional round trip.

(6) The river loses out as a winter mooring place by reason of lack of room. At present only 20 to 30 of the 355 vessels of the Lake Carriers' Association lay up in Cleveland. When one realizes that each boat spends from $5,000 to $25,000 in repairs and new equipment each spring, Cleveland's loss through inability to accommodate more vessels is apparent.

MAKING THE CUYAHOGA NAVIGABLE FOR LARGE FREIGHTERS

After nearly a century of wishing for and talking about a straightened Cuyahoga, Cleveland in 1939 substituted action and began improving the river. This involved an expenditure of approximately $11,000,000 of Federal and city money. It included cutting back nine of the worst bends, widening the channel at critical points, and removing and rebuilding old narrow bridges to permit the largest freighters on the lakes to navigate the river safely and with reasonable speed (Fig. 3). It should be realized, however, that navigation is not easy for the largest boats even now. Steel bulkheads necessary for cutting back the three sharpest bends were installed. At Collision Bend (Fig. 3) an appreciable area, four acres in size, was removed. Here was made a turning basin which accommodates the largest freighters on the lakes. Thus Cleveland now has an industrial harbor, including the Old River and connecting slips, 13 miles long. At present only about half of this is used.[13] The new channel has a minimum width of 200 feet, is 250 feet wide at the docks and has a project depth of 21 feet.

BENEFITS FROM RIVER IMPROVEMENT

Improvements in the navigable part of the stream have:

(1) Made the river accessible to the largest freighters plying the lakes.

(2) Facilitated and encouraged commerce by eliminating unnecessary delays.

(3) Reduced the increasing expenditures for dredging which averaged about $135,000 per year.

Improvement of the upper river (above the present head of navigation) would:

(1) Provide sites for manufacturing industries leaving the entire lake front from East 9th Street to Gordon Park available for warehouses and concerns whose principal business is the transshipment of materials from boat to rail or truck.

(2) Make available for heavy industries

[13] *Report of the Chief Engineer of the United States Army*, 1938, p. 1587.

(a) a new tract of about 2500 acres in the upper valley;
(b) an ample supply of industrial water of good quality at reasonable cost.

(3) Prevent recurrence of flood disaster with attendant damage to property, interruption to business and danger to life.

SUMMARY

It has been stated how very important a rôle the Cuyahoga River played in Cleveland's founding and in its early industrial and commercial development (Figs. 5 and 7). The city's great iron and steel industry has grown up in the Flats (the lower Cuyahoga Valley), and is dependent upon the stream's water-borne traffic. It has also been pointed out that the river is today a highway serving a special kind of traffic, primarily that related to the iron and steel industry. Cleveland is one of the most strategically located cities in the United States for making and marketing iron and steel. This was pointed out recently by the president of the Republic Steel Corporation, third largest in the United States:

> "It is needless to say that as it became known that Republic was contemplating the construction of this mill (the new continuous wide strip mill), pressure was brought to bear upon the corporation officers to locate it in various cities. A careful analysis reduced these cities to three and of these three, Cleveland was finally chosen. Cleveland was chosen because our engineering studies showed that we could more economically produce and market sheet and strip steel in Cleveland than we could in any other city."[14]

The Cuyahoga River should have received long ago treatment similar to that of a much used street or highway characterized by marked deficiencies; its great traffic justified improvement, for the river constitutes the life blood of the city's important iron and steel industry which alone employs an average of about 8,500 men, has an annual payroll of $17,000,000, and pays in taxes about $1,400,000 per year.[15] In 1937, 6,000 vessels handled about 13,000,000 tons of freight on the river.[16]

That Cleveland's prolonged procrastination was indefensible is indicated by United States Army Engineer reports covering the past two decades which show that water transportation on the Great Lakes increased about 65 per cent whereas Cleveland's portion decreased 11 per cent. Cleveland's poor showing is in no small part attributable to its failure to improve the

[14] T. M. Girdler, "Why Cleveland Was Chosen," *The Clevelander*, September, 1937. p. 3.

[15] *Report of Charles Keller, op. cit.*, p. 18.

[16] D. B. Gillies, "The River: A Problem and An Asset," *The Clevelander*, February, 1938, p. 40.

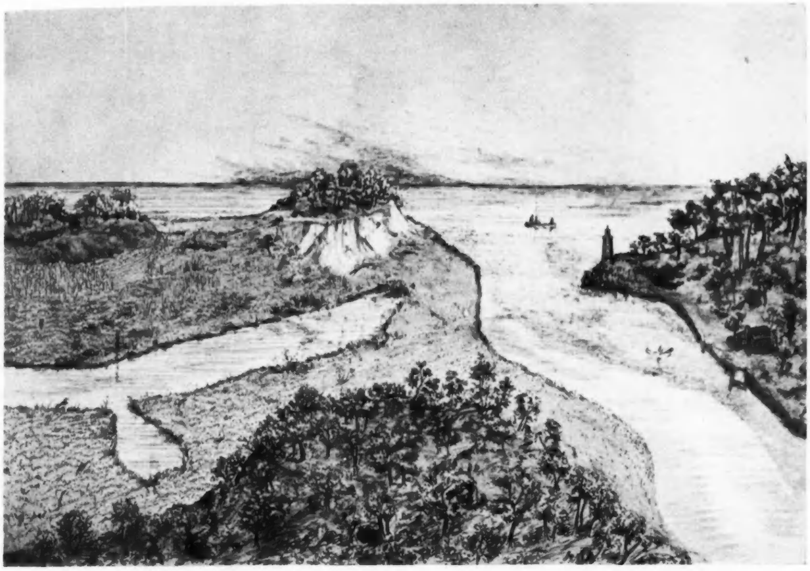

FIG. 7.—The mouth of the Cuyahoga as it appeared in 1800. Formerly the mouth was about 700 feet west of the present outlet and was obstructed by a sand bar over which people walked as late as 1820. It was in this locality and at about this time that Cleveland's industrial development began, though the first cargo of iron ore was not brought down from the Upper Lakes Region until 1853. This was the first lighthouse to be built on the southern shore of Lake Erie—a significant fact since it greatly stimulated the commercial life of the city; moreover, it had much to do with Cleveland's being selected as the northern terminus of the Ohio Canal. (Courtesy of Western Reserve Historical Society and Cleveland Engineering Society.)

industrial or river harbor. Moreover, traffic each year was paying a heavy toll in vessel damage, direct cost, and time of transport. For Cleveland's iron and steel industry to compete with that of other ports on the Great Lakes, the Cuyahoga must accommodate the largest freighters. The work now completed should mark a new era in Cleveland's manufacture of heavy products and in its water transportation.

Western Reserve University,
February, 1940.

RAY HUGHES WHITBECK, 1871–1939

Ray Hughes Whitbeck: Geographer, Teacher, and Man

FRANK E. WILLIAMS

With the passing of Ray Hughes Whitbeck, July 27th, 1939, Geography lost an untiring exponent and geographers lost a beloved colleague. He was born in Rochester, New York, April 2, 1871. The Whitbeck family is of Dutch origin and the first of them came to America previous to 1700. His maternal ancestry was Scotch—his great-great-grandfather John Hugh came from Musselborough, Scotland in 1753. Of Whitbeck's early life we know little. His father was a merchant in one of the little villages in the hilly plateau lands of southern New York. He apparently was either not interested or unable to aid his son in getting an education and whatever encouragement Whitbeck had to go on with his schooling came from his mother.

Whitbeck received his early education at Pike Seminary (N. Y.) and the normal school at Geneseo, which teacher's training course he finished at the age of twenty-one. After completing his work at the normal school he was principal of Pike Seminary for four years and of the Schuylerville High School for two years. At the end of this period he resolved to advance himself by further study. With this desire in mind he entered Cornell University in 1900 and obtained his A. B. degree in 1901. This may well be considered an important step in his career. That he would have been a good teacher without advance study there is no doubt, but his work at Cornell developed in him new interests. Here he came under the influence of the noted physiographer, R. H. Tarr. As departmental assistant in Geology, Whitbeck was inspired by Professor Tarr and stimulated by a group of fellow students in geography and geology.

He was unable at that time to continue advanced work in his chosen field of geography and after a year as assistant in physical geography at Cornell he accepted the position of supervisor in the State Model School of New Jersey at Trenton which position he held for eight years. In three of those years he lectured at Adelphia College, Brooklyn. While at Trenton, in 1906, he was elected to membership in the Association of American Geographers of which he was president in 1925.

In 1909 he was called to the University of Wisconsin where he remained until his retirement in 1937 and where he did much to develop geography to the major importance it holds at that institution. It was my privilege and pleasure, as an assistant in the department at Wisconsin, to welcome him and help him in his first summer's work there. He won my admiration and devotion at once and thus began a cherished and continued friendship.

He had many requests to do work in summer sessions, some of which he accepted when he could be spared by his own institution. He was editor of the Journal of Geography from 1910 to 1919 and after resigning as editor continued his interest as associate editor until his death. He was active in helping the promotion of the National Council of Geography Teachers and its president in 1920. The Distinguished Service Award of the Council was bestowed upon him in 1933.

So much is a brief outline of the general events of Professor Whitbeck's life, most of which could be obtained from Who's Who, White's Biography and other similar publications. But I wish to speak briefly this morning about Ray Hughes Whitbeck as geographer, teacher and man. He was a prolific writer having been the author and co-author of several books in addition to well over fifty papers in geographical publications and several others in related magazines. In these articles he touched a wide range of subjects such as topical, descriptive, regional, physiographic, presentation (rather than pedagogy), age of the earth, laboratory work, irrigation, industrial relations, mineral industries, environment, tests, history of geographical development, "points to emphasize," and "don'ts." In an article in the Journal of Geography in 1906 he proposed twelve geographic principles.

In a recent memorial, one of his colleagues at Wisconsin, who knew the work of his later years best of all, said, "He was led inevitably to think and write as much for the teacher as for the broadening of scholarship and the accumulation of knowledge in his chosen field. It was his greatest satisfaction to write for students and teachers the striking descriptions and interpretations of geography, newly oriented, and stated with that simple clarity of which he was a master."[1]

It must not be inferred, however, that his whole interest was in clearing the way for the teacher through articles on presentations and in his textbooks. He had the power of careful analysis and keen observation which led to the production of many papers and books on regional geography. He was particularly interested in the effects of glaciation on man's activities, and one of his best studies was "Economic Aspects of the Glaciation of Wis-

---

[1] V. C. Finch, in *The Journal of Geography*, Vol. XXXVIII, p. 252, September, 1939.

consin" in which he clearly demonstrated the contrasts between the glaciated and driftless portions of the State.

He rarely attempted to bring attention to his work by journalistic methods or striking headlines. His early writings showed much of the terseness of expression with which we are familiar in his later work. In 1903 he wrote an article entitled "The Glacial Period and Modern Geography" in which we find, "The work of the glacier in New York State was, on the one hand, less spiteful than in New England, and on the other, less beneficient than in the states farther west."

It is difficult to evaluate the geographic philosophy of any geographer who wrote over such a large span of years as Whitbeck. Like many others his ideas relating to the importance of environment went through progressive changes, but in his later years I believe it may be summed up by quoting his own words taken from his presidential address in Madison, in 1925, entitled "Adjustments to Environment in South America: An Interplay of Influences."[2]

> "But in the last analysis, it is probable that certain regions and peoples are advanced mainly because of the highly favorable environments in which the race has evolved: that their initiative, energy, and intelligence are products of underlying environmental factors operating upon these peoples for long ages. It is the old question of race versus place; and the geographer will hold that the masterful race is the product of the place that nourished it. And so our cycle returns upon itself—the place makes the race and then the race progressively remakes the place."

As a teacher he was superb. His sincerity, personal charm, his interest in his students, his early training, and his careful preparation made him one of the most liked of professors on the various campuses where his services were requested. He regarded it his duty to present his work as clearly as possible and to select only those topics that he believed to be of value. As early as 1906, he published in the Journal of Geography an article on "The Fundamental and the Incidental in Geography." He there recognized that the subject matter in geography is limitless and a selection must be made. He was not particularly concerned as to whether his approach might be inductive or deductive. Neither was he interested in conscious pedagogical principles. He worked hard in preparation, often writing out carefully the questions he wished to have discussed. Each meeting of the class required a new preparation on his part although the subject was one with which he was completely familiar. I believe his attitude toward presentation is well illustrated by an incident that I remember well. This occurred many years

[2] *Annals of the Association of American Geographers*, Vol. XVI, p. 11, March, 1926.

ago at the University of Wisconsin. The authorities there became interested in the improvement of teaching on the part of the members of the faculty. They hired a so-called expert who came and at considerable expense prepared a long and formidable questionnaire. Professor Whitbeck took a look at it, picked up his blue pencil and wrote across the front "The way to improve teaching is to improve it," and sent the document back. He believed that knowledge of the subject, a desire to impart that knowledge, and an interest in the student must result in successful presentation. This careful work on his part for every discussion was reflected in his writings which are noted for their simplicity and clearness.

As a man he was beloved by all: honest, dependable, ever ready to help and at the same time insistent on giving others credit for their ideas. He was deeply religious, but always tolerant and non-critical in his relations with others. His bequest shows his interest in religion, education and friends. While never miserly, he was always frugal and believed that not only individuals should pay as they go, but that the same principle should apply to those in charge of government funds. With the same honesty of purpose he worked just as hard when he was in government service at Washington as in his office at home. He was, until disease afflicted him in his last few years, a tireless worker, but he was never so busy that he would not stop his work to help a colleague on a problem or give advice to his students. In 1930 in writing of another beloved fellow geographer he very well described himself. "But still more surely that charm of style is an expression of the humanity and character of the man himself. We love to read what Brigham writes because his writings reveal the lovable nature of the writer."[3] Seldom is found in one man the zest for his field of knowledge, the desire for the dissemination of geographical interpretations to others, the facility for expression on paper and in the classroom, and the genuine interest in his fellow man as was present in the personality of Ray Hughes Whitbeck.

BIBLIOGRAPHY

Geography of New York State. Macmillan Co.
Supplement to Tarr and McMurray Geographies 1901

Comparisons in Elementary Geography
Atlantic Educational Journal 1902

The Teachers' Preparation in Geography
Atlantic Educational Journal 1902

The Pre-Glacial Course of the Middle Portion of the Genesee River
Bull. Am. Geog. Soc. Vol. 34, pp. 32–44 Feb. 1902

[3] Albert Perry Brigham, "Human Geographer," *Annals of the Association of American Geographers*, Vol. 20, pp. 72–81, June 1930.

The Glacial Period and Modern Geography
Journal of Geography. Vol. 2, pp. 21–25 Jan. 1903
Response to Surroundings, A Geographic Principle
Journal of Geography. Vol. 3, pp. 409–412 Nov. 1904
Practical Work—School Geography
Read before the 8th International Geog. Congress, New York 1904
Published in report pp. 1025–1029 Washington, D. C. 1904
Also in Journal of Geography. Vol. 3, pp. 374–379 Oct. 1904
Geographic Names in the United States and the Stories They Tell
Nat. Geog. Mag. Vol. 16, pp. 100–104 Mar. 1905
Results to be Expected from a School Course—Geography
Journ. of Geog. Vol. 4, pp. 149–154 Apr. 1905
Geography of New Jersey. Macmillan Co.
Supplement to Tarr and McMurray Geographies 1906
The Fundamental and the Incidental in Geography
Read before the N. J. Teachers' Assn. Atlantic City Dec. 1905
Journ. of Geog. Vol. 5, pp. 66–73 Feb. 1906
Placing the Emphasis in Teaching the Geography of Europe
Journ. of Geog. Vol. 6, pp. 1–7 Jan. 1907
Secondary School Geography—What Shall It Be?
Read before N. J. Teachers' Assn. Princeton May 1907
Sch. Sci. and Math. Vol. 7, pp. 579–582 Oct. 1907
Geography in the Elementary Schools
Read before the Science Section of the N. E. A. at Cleveland July 1908
Published in the Proceedings 1908
Geographical Influences in the Development of New Jersey
Read before the Assn. Am. Geog. Chicago Dec. 1907
Journ. of Geog. Vol. 6, pp. 177–182 Jan. 1908
Specialization in Industry by Certain Cities, with Particular Reference to Trenton, New Jersey
Read before the Assn. of Am. Geog. Baltimore Jan. 1909
Journ. of Geog. Vol. 8, pp. 32–38 Oct. 1909
Laying the Emphasis in Teaching the Geography of Asia
Journ. of Geog. Vol. 10, pp. 51–57 Oct. 1911
Regional Peculiarities in Place Names
Bull. Am. Geog. Soc. Vol. 43, pp. 273–281 Apr. 1911
Contrasts Between the Glaciated and Driftless Portions of Wisconsin
Bull. of the Geog. Soc. of Phila. Vol. 9, pp. 114–123 July 1911
Geographical Influence in the Development of New York State
Journ. of Geog. Vol. 9, pp. 119–124 Jan. 1911

Industries of Wisconsin and Their Geographic Basis
Ann. Assn. Am. Geog. Vol. 2, pp. 55–64 1912
Suggested Modifications in High School Geography
Read before Cent. Assn. of Sci. and Math. Teachers, Chicago Dec. 1911
Journ. of Geog. Vol. 10, pp. 184–189 Feb. 1912
Commercial Geography as a Secondary School Study
Read before Comml. Studies Sect. N.E.A. Chicago July 1912
Journ. of Geog. Vol. 11, pp. 49–55 Oct. 1912
Geography and Industries of Wisconsin
Wis. Geol. and Nat. Hist. Survey, Bull. 26 1913
Mammoth Cave
Journ. of Geog. Vol. 11, pp. 336–341 June 1913
Geography in City High Schools
Read before Science Section, N.E.A. St. Paul July 1914
Journ. of Geog. Vol. 13, pp. 1–8 Sept. 1914
Manufacturing Industries of Wisconsin
Journ. of Geog. Vol. 12, pp. 257–262 Apr. 1914
Economic Aspects of the Glaciation of Wisconsin
Read before Assn. Am. Geog. Princeton Jan. 1914
Ann. Assn. Am. Geog. Vol. 3, pp. 62–87 1914
A Geographical Study of Nova Scotia
Read before Assn. Am. Geog. Princeton Jan. 1914
Bull. Am. Geog. Soc. Vol. 46, pp. 410–419 June 1914
Geography of the Fox-Winnebago Valley
Wis. Geol. and Nat. Hist. Survey, Bull. 42 1915
Ideals and Aims in Elementary Geography
Journ. of Geog. Vol. 14, pp. 65–70 Nov. 1915
The St. Lawrence River and Its Part in the Making of Canada
Read before Assn. Am. Geog. Chicago Dec. 1914
Bull. Am. Geog. Soc. Vol. 47, pp. 584–593 Aug. 1915
Scenic Routes to the Pacific Coast
Journ. of Geog. Vol. 13, pp. 306–310 June 1915
Economic Geography; Its Growth and Possibilities
Read before the Comm. Sect. Iowa Teachers' Assn. Nov. 1915
Journ. of Geog. Vol. 14, pp. 284–290 Apr. 1916
The Growth of Geography in American Colleges and Universities
Bull. Ill. Council of Geog. Teachers. Series I, No. 7 May 1917
The Need of Broad Gauge Courses in Geography
School Review. Vol. 26, pp. 199–204 Mar. 1918
The Influence of Geographical Environment upon Religious Beliefs
Read before the Assn. Am. Geog. New York Dec. 1916

Geog. Rev. Vol. 5, pp. 316–324 Apr. 1918
Suggestions for Teaching Elementary Geography
Journ. of Geog. Vol. 16, 17, pp. 121–128, 171–176
Dec. 1917, Jan. 1918
The Country's Call for Geographers Today and Tomorrow
Read before the Cent. Assn. of Sci. and Math. Teachers Chicago
Nov. 1918
School and Society. Vol. 9, pp. 223–228 Feb. 1919
Geography in American and European Universities
Journ. of Geog. Vol. 18, pp. 129–141 Apr. 1919
Our Iron-Clad Civilization
Sci. Mo. Aug. 1919
Immigration in the United States
Geog. Journ. Vol. 54, pp. 221–231 Oct. 1919
Through the Panama Canal
Journ. of Geog. Vol. 19, pp. 223–232 Sept. 1920
The Influence of Lake Michigan upon Its Opposite Shores
Ann. Assn. Am. Geog. Vol. 10, pp. 41–55 1920
Human Geography
Educational Review—Fredericton, N. B. Jan. 1920
Thirty Years of Geography in the United States
Presidential Address before the Nat. Council of Geog. Teachers
Chicago, Dec. 1920. Journ. of Geog. Vol. 20, pp. 121–128
Geography and Economic Development of Southeastern Wisconsin
Wis. Geol. and Nat. Hist. Survey, Bull. 58 1921
Geography and Man at Panama
Bull. Geog. Soc. of Phila. Vol. 19, pp. 1–8 Jan. 1921
High School Geography. Macmillan Co. 577 pp. 1922 Revised 1929
Geographical Relations in the Development of Cuban Agriculture
Geog. Rev. Vol. 12, pp. 223–240 Apr. 1922
Fact and Fiction in Geography by Natural Regions
Read before the Nat. Council of Geog. Teachers, Ann Arbor Dec. 1922
Journ. of Geog. Vol. 22 Mar. 1923
Economic Geography (College text) with V. C. Finch
558 pp. The McGraw-Hill Book Co. 1924 Revised 1929
Industrial Geography (High School text)
608 pp. The American Book Co. 1924 Revised 1929
Traditional Geography and the Present Trend
Read before the Nat. Council of Geog. Teachers, Cincinnati Dec. 1923
Journ. of Geog. Feb. 1924

A Science of Geonomics
Read before the Assn. of Am. Geog. St. Louis Dec. 1919
Ann. Assn. Am. Geog. Vol. 16, pp. 117–123 Sept. 1926
Adjustment to Environment in South America; An Interplay of Forces
Presidential Address before the Assn. of Am. Geog. Dec. 1925
Ann. Assn. Am. Geog. Vol. 16, pp. 1–11 1926
Economic Geography of South America (College text)
430 pp. The McGraw-Hill Book Co. 1926 Revised 1930 & 1936
The Coast Waters and Coast Lands of Peru
Journ. of Geog. Vol. 25, pp. 41–52 Feb. 1926
Manufacturing in the United States
Journ. of Geog. Vol. 27, pp. 207–219 Sept. 1928
The Chileans and Their Country
Read before the Assn. of Am. Geog. New York Dec. 1928
Ann. Assn. Am. Geog. Vol. 19, pp. 149–156 Sept. 1929
Albert Perry Brigham, Human Geographer
Ann. Assn. Am. Geog. Vol. 20, pp. 72–81 June 1930
Chilean Nitrate and the Nitrogen Revolution
Econ. Geog. Vol. 7, pp. 273–83 July 1931
Ellen Churchill Semple, Geog. Rev. Vol. 22, pp. 500–501 July 1932
The Geographic Factor (with Olive J. Thomas) The Century Co. 1932
The Agricultural Geography of Jamaica
Ann. Assoc. Am. Geog. Vol. 22, pp. 13–27 March 1932
Irrigation in South America (with Dorothy Sisson)
Econ. Geog. Vol. 9, pp. 198–210 Apr. 1933
Lesser Antilles—Past and Present
Ann. Assoc. Am. Geog. Vol. 23, pp. 21–26 Mar. 1933
The Working World (with Loyal Durand and J. R. Whitaker)
American Book Co. 1937

University of Pennsylvania,
December, 1939.